Water spectrum

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Water spectrum

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COVER: In the final analysis, this is what the hue and cry is all about–the preservation of our water resources for future generations through the rational compromise of competitive water use demands. It's the bottom line.

THE LAND USE DILEMMA

by **Lance Marston**

For many years to come America's environmental and energy challenge will be rooted in the nation's land. It is there—on the land—that we must strike a balance between the material needs of our society and the awakened concern for a high-quality natural environment.

America's economic growth and standard of living are a remarkable achievement. We have our land to thank for much of that. On our fertile soil at one time we could grow enough to feed the world—and on occasion we did. From its subsurface we have extracted the substances that have made us preeminent among the world's industrial nations. Recent growth has been so rapid that in one short generation we have built more homes, roads, schools, and public facilities than in the previous three centuries of our history. As we have used our lands to fashion a society geared to social and economic expansion, we have paid a price—one we are just beginning to measure.

A deteriorating landscape arouses us to anger, sadness, and frustration. In many of the population-growth regions of the country, we see a recurrent pattern of dreary housing projects, subdivisions, and commercial-strip developments sprawling indiscriminately across the countryside. The crowded highways and schools and the loss of productive farmland, watershed areas, and esthetically valuable open spaces are but a few of the results of haphazard growth and poor community planning.

Many states and local communities are virtually being swamped with second-home and recreational developments. In Arizona, New Mexico, and Colorado, millions of acres have been sold for development. Many of these areas lack water, roads, and sewers and thus are generally unsuited for building.

According to the U.S. Department of Agriculture, every decade we lose more than a million acres of productive farmland to nonagricultural uses. Recent worldwide food shortages, the rising cost of food, and the continuing drought in major food-producing regions of this country are beginning to awaken us to the need for preserving prime agricultural land. Across the nation, income from food and fiber production rose roughly 70 percent in the last decade, while the value of the land producing these goods rose almost twice that. This kind of disparity creates immense pressure for development. Farmers are often forced to sell because they simply cannot meet continually rising property taxes.

Without adequate land use planning, population growth has often been translated into urban sprawl. Dorn C. McGrath

As we grope for answers to our serious energy problems, we are beginning to recognize that state and local government land-use practices can play a major role in determining energy use. As long as housing developments continue to spread in larger and larger circles around our metropolitan centers—without more thought to how people will get to work efficiently or without taking into account regional mass transportation opportunities and plans—we guarantee more travel by personal automobile. Developing planned growth programs that force consideration of transportation strategies is an important part of solving the energy problem.

What we are doing to our natural environment is an insult to common sense. What is worse, the effects of indiscriminate land use are frequently prolonged and may even be irreversible. How, then, can we assure better land-use practices?

With the advent of the national environmental movement in 1969, the federal government and a few states—Vermont, Maine, Florida, and California among them—sought legislation to bring land-use conflicts under control.

Among the key questions this legislation addresses were:

☐ What levels of government should be involved in planning major conservation or development projects that will affect citizens in areas beyond the one that has the final say?

☐ What techniques of planning and regulation should be used in major land-use actions affecting more than one jurisdiction?

Government fragmentation and home-rule myopia are often a major source of problems. The United States is

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composed of more than 50,000 local governments—3,000 counties, 18,000 cities and villages, 16,000 towns, 25,000 school districts, and 18,000 special districts. Each of these jurisdictions exercises direct or indirect influence over land use. For many years now, the local governments have played a protective role, using land-use-control authority granted by state governments but inspired by the federal government's model zoning codes of the 1920s. Regulating the location of residential, commercial and industrial land uses has been largely a local matter.

A change in the pattern of development after World War II, however, began undermining the effectiveness of local land-use control. Encouraged by federal spending programs, growth began to shift from small, incremental development to large-scale projects. Federal capital investment subsidies in water and power development, housing and transportation induced urban sprawl. New single-purpose government organizations, such as housing or highway agencies, optimized single development and functional objectives without regard to economic, social and environmental effects or to public preferences. Money poured into development that was indifferent to comprehensive planning, conservation of natural and cultural resources, and air and water quality, and growth took place in areas lacking the technical and financial means to guide and support it.

The resulting conditions have contributed to a public skepticism that the Rockefeller Brothers task-force report on land use and urban growth characterized as a new mood in America: ". . . Increasingly, citizens are asking what urban growth will add to the quality of their lives. They are questioning the way relatively unconstrained, piecemeal urbanization is changing their communities and are rebelling against the traditional processes of government and the marketplace, which, they believe, have inadequately guided development in the past."[1]

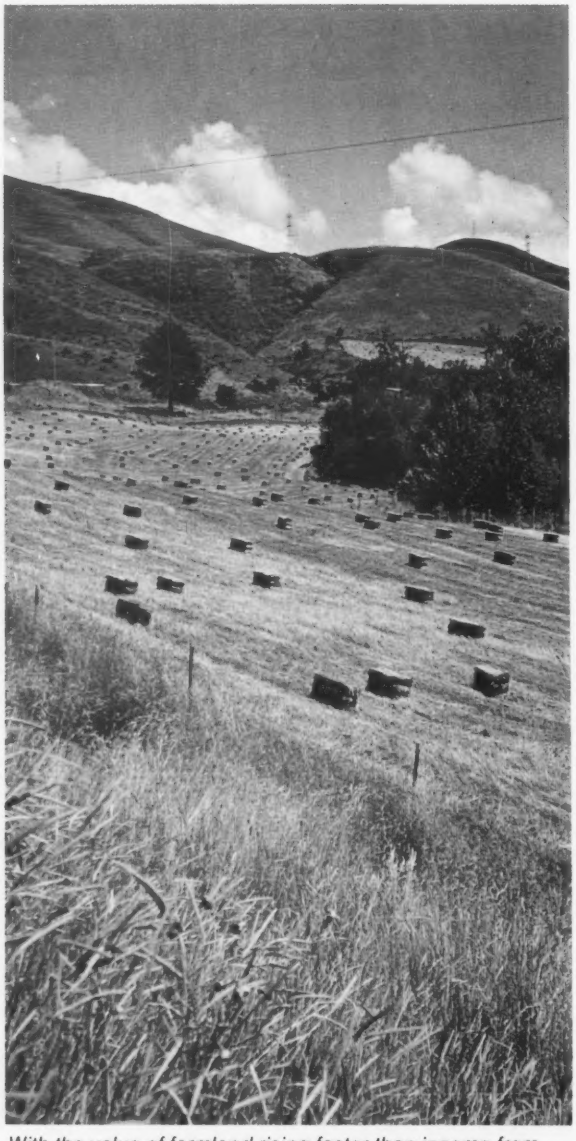
In attempts to regain some measure of public control over land-use decision-making, people in scores of communities have forced adoption of "slow growth" or "no growth" plans. Efforts designed to give local governments time to alleviate the overwhelming impact of past development excesses and to devise policies and capital-improvement plans to guide future development are exemplified by communities such as Ramapo, New York, and Petaluma, California.

Every decade a million acres of productive farmland are lost to other uses. BLM

Unfortunately, a growing number of jurisdictions in the United States are adopting ordinances to exclude any kind of land use that would impose an environmental, social, or tax burden on its citizens. Such exclusionary policies often delay or even prevent construction of power plants, sanitary landfill facilities, wastewater treatment plants, and other needed facilities. Furthermore, by rejecting a moderate-income housing project, for example, because of fears of a mushrooming population, a rising crime rate or a need for more schools, one community may be passing off its fair share of the region's housing onto a community already carrying a

Commercial strip development has become a common blight in and around American cities. HUD

[1]*The Use of Land: A Citizens Policy Guide to Urban Growth,* a task force report sponsored by the Rockefeller Brothers Fund, William K. Rudy, editor (New York, Thomas Y. Crowell Co., 1973).



With the value of farmland rising faster than income from food and fiber production, property taxes have forced many farmers to sell their land for development. BLM

disproportionate share of environmentally and financially burdensome projects.

Pressures for locating large-scale development projects now are strongest in the undeveloped perimeters of our cities and in the nation's rural areas. Countless public and business projects are being "exported" to these areas because of exclusionary zoning in metropolitan areas and rising citizen reaction there to development that does not pay its way. But many of the rural areas are not prepared for growth. The Council of State Governments estimates that, of the 1.5 billion acres of nonfederal land, about two-thirds—much of it in rural regions—lacks both a land-planning and management capability and the financial resources to cope with many kinds of large-scale recreational, second-home, energy, and industrial development.

The costs of increased congestion and pollution, the loss of productive agricultural land, and the increased burden of taxes to subsidize water, sewers, and roads for second-home subdivisions are raising the ire of rural citizens. They too are now seeking restrictive ordinances and attempting to attract development that is both clean and pays its way. They are asking: Why should we pay for projects that benefit other communities? Why should we subsidize development that cannot pay its way? Why should we sacrifice community values and traditions to meet the needs of a distant metropolitan area?

In this context of competition for land resources between urban and rural areas, the federal government in the early 1970s proposed major reform of our public and private land-use practices. The task was approached in three ways. First, the federal public-lands agencies such as the U.S. Forest Service and the Bureau of Land Management (BLM) were granted authority to plan and manage the national forests and the public lands in the West toward multiple-use objectives. The Forest and Rangeland Renewable Resources Planning Act of 1974 and the Federal Land Policy and Management Act of 1976 repealed outmoded laws and mandated new procedures. The Forest Service and BLM are now required to inventory public lands, conduct sound land-use plans with public participation, manage in accord with multiple-use principles, conduct wilderness reviews, record mining claims, and perform myriad other responsibilities, all subject to close Congressional oversight.

This public lands legislation also contains strong policy and procedural provisions requiring that the public-lands inventory, planning and implementation process be coordinated with other levels of government and be consistent with state and local plans to the maximum extent permitted under federal law. This new policy is designed to reduce tensions and conflicts between public-lands agencies and non-federal jurisdictions adjacent to public lands, especially on major issues like energy development plans and land withdrawals and sales. The principle is that people should not be subjected to a land-use action that significantly affects their economic, social and environmental well-being without an opportunity to express an opinion and preference on the proposed action.

This same principle provided some of the underpinning for the second component of the federal land-reform effort. This component centered on legislation to encourage state governments to work with local jurisdictions in developing policies, procedures, and regulations that would help resolve conflicts among users and governmental jurisdictions in competition for land resources. Although national land-use policy legislation was to be the centerpiece of this effort, the Coastal Zone Management Act (CZMA) of 1972 was the only comprehensive land-management legislation involving nonfederal land that won Congressional approval.

The Coastal Zone Management Act expressed a national concern about the increasing competition and conflicting demands of urbanization, energy development, industry, and recreation in the coastal zones. The Act is an explicit recognition of the important and sometimes incompatible values of our nation's coastal regions, which offer:

☐ Home for more than half of our nation's population,

The impact of the highway on the urban environment is illustrated by two views of San Francisco's Ferry Building, one showing the structure in 1925, the other, as it appears today. Dorn C. McGrath

☐ Estuaries that are among the most productive ecosystems on earth,

☐ Reliable sources of water and other attractions for manufacturing and energy facilities,

☐ Recreation.

More importantly, the Act declared that further haphazard, unrestrained development is not in the national interest.

Simply stated, the Act provides financial incentives for states to work with local governments in developing ground rules to resolve competing demands for coastal resources. It urges establishment of policy and criteria to determine which of various uses take precedence—production or pollution control, housing or home rule, bridges or open water, highways or open land. And, finally, the Act calls for a more explicit statement of how decisions will be made and who will make them. Specifically, the Act requires the states to identify the boundaries of the coastal zone, define permissible land uses within the coastal zone, inventory and designate areas of particular concern, consider priorities of use, and develop criteria for controlling land and water uses.

Even though the CZMA is a voluntary program, all of the 34 eligible coastal states and territories are participants. By the end of 1978, at least 11 states are expected to have programs capable of implementing agreements on coastal land-use goals.

Herein lies the third element of the federal government's strategy for rationalizing the nation's land-management system. It is a prototype concept that goes by the simple term "federal consistency": once a state has an acceptable coastal-zone program, it receives the commitment of federal agencies to conduct their activities in a manner consistent with the state program.

Under this provision, the state for the first time gains a measure of control over federal decisions because it forces single-purpose federal-subsidy programs—water or highway programs, for example—to conform to an integrated state program for coastal planning and management. Moreover, local jurisdictions, attracted by the opportunity to gain some control over federal programs, have begun the cooperative planning that qualifies them, under the Act, to exercise that control.

At this point, it should be obvious that we still have an unfinished national land-reform agenda. Of the 2,264 million acres of land in the United States, most of the 763 million acres of public lands and the 140 million acres of land in the coastal regions are now being managed under evolving methods that, it is hoped, will permit us to anticipate future growth requirements and allocate our land resources more wisely.

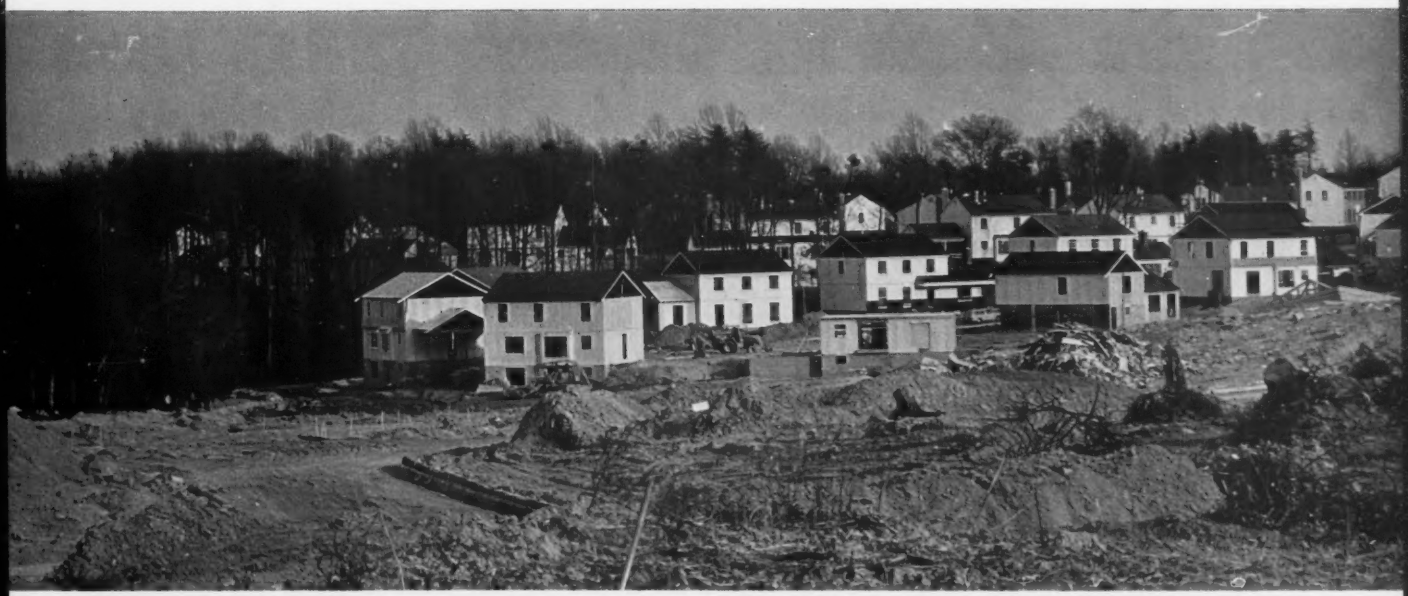
But what about the remaining 55 percent of the nation's land—now called the upland or inland area? This was the area to be covered by land-use legislation defeated in the 94th Congress. Interestingly, the land-use legislation embodied many of the same objectives and financial incentives as the coastal-zone legislation, which the House of Representatives had earlier endorsed by a vote of 376-6.

Coastal-zone and land-use legislation rode the crest of the environmental movement and the spirit of intergovernmental cooperation that marked the early 1970s. The Coastal Zone Management Act came just under the legislative wire as the impetus behind the proposals subsided; CZMA funds were impounded for more than a year by the Nixon Administration. Land-use legislation bogged down in the House of Representatives in efforts to integrate public and nonfederal land reform into a single legislative proposal. There had always been a small but vocal band of land-use control opponents, who argued that the legislation was nothing short of national zoning and would lead to wholesale confiscation of private property. They increased their numbers, however, when they used the 1973 economic and energy crisis to argue that proposed land use statutes were really "no growth" legislation. The final blow came when President Nixon unexpectedly withdrew support for the legislation, which had enjoyed a high priority on his administration's legislative agenda. Efforts to arouse President Ford's interest in land use were to no avail.

What of the future? The land-use issues in the "upland" areas are more critical than ever before. The pressures for coal and other energy development mount daily. And there is the spectre of more large-scale industrial and public-facility development moving inland because of increased planning and regulatory constraints, such as CZMA, in the coastal regions. The impetus to develop coordinated public-lands planning will be frustrated by the absence of rational land-management programs in most western states. Will development occur at the expense of prime agricultural lands and natural areas not suited to major development, such as important watersheds and wetlands? Although the environmental movement has suffered some recent setbacks as a result of the national economic plight and the energy crisis, it appears to be gaining its second wind. The recent enactment of surface-mining legislation was a major victory for more rational land use. One might expect that attention would now focus on the broader land-use problem, but there are some clouds on the horizon and reasons for proceeding cautiously.

First, any new land-use legislation proposal must have a sound philosophical base and, if possible, a working model that reasserts the principles of limited government authority and provides for greater citizen involvement in decision-making. The American Law Institute's (ALI) Model Land Development Code provided the intellectual focus for the national debate on both land-use and coastal-zone legislation. Now, however, with about six years of federal, state, and local government experience under CZMA, we have also a tangible model of the ALI concept. Even though the CZMA program will have just 11 states in the implementation phase by the end of this year, coastal-zone planning has already produced significant resource, environmental, and social benefits, according to a recent study by the Real Estate Research Cooperation.

Second, the future of land-use legislation will depend upon initiatives taken by the Carter administration. Although President Carter announced support for land-use legislation during his campaign for the presidency, Secretary of the Interior Cecil Andrus has informed Congress that the issue is not a high priority on the administration's legislative agenda. The



Rural areas and the peripheries of urban areas now face the greatest pressures for development. Dorn C. McGrath

administration's current emphasis is on government reorganization and consolidation of federal programs. Governors and local officials have expressed some desire for a consolidation of programs providing land-resource-planning assistance. Probably careful analysis and consideration of how the more than 18 federal planning-assistance programs could be reoriented to provide more support to state and local elected officials will occur before any land-use initiatives are offered by the administration.

Whatever course the administration pursues, state and local governments need financial and policy encouragement and assurances that they will have greater influence over federal actions affecting their jurisdictions. But federal assistance should be authorized only if these jurisdictions adopt land-use reforms that, at a minimum, answer the following needs:

(1) Better techniques to identify and describe—early in the planning process—conflicts among proposals for large-scale

Demand for recreation has led to second-home developments built on fill, like this Florida project.

Will development take place at the expense of wetlands and other areas not suited to large-scale construction?

The uses–and misuses–of land often determine how water resources can be used. Dept. Urban & Regional Planning, George Washington University

Shoreline development can preserve esthetic values if it is carefully planned and designed. Dorn C. McGrath

developments in areas with significant natural values. This is particularly important when the consequences of loss or damage of these areas would be long-term.

(2) The opportunity for people to evaluate all major proposals likely to affect them. This need could be satisfied by establishing a governmental forum in which affected individuals could consider various land-use alternatives and express their preferences for particular courses of action.

(3) Strengthened mechanisms to implement and enforce decisions resulting from a popularly supported planning and management process.

Similar needs are felt in the area of water resources management. The Carter administration's current National Water Policy Study is considering meeting these needs as a way of strengthening federal-state river-basin planning and implementation. The Water Resources Council is currently working with states and river-basin commissions to develop a more rational regional water-management process, with emphasis on:

☐ Ensuring more serious participation in interstate water planning by state and federal agencies, and,

☐ Developing a framework to require that all federal development projects, grants and regulations significantly affecting the use of water and related land be consistent with approved interstate water management plans.

In summation, the time has come to commit ourselves to developing the tools of reform and to establishing intergovernmental planning and coordinating processes. This will ensure that the continuing development and utilization of our natural resources, and of the land areas which harbor them, will be based upon well-defined, coordinated, long-term state, local, and national goals—not on unilateral decision-making influenced by short-term economic or policy expediencies at each level of government.

Reform, rational procedures, careful analyses and systematic coordination—all are more difficult and time consuming than simply muddling along and allowing circumstance to determine the future appearance of our landscape. If we truly value our land, however, we must begin our comprehensive planning now. If we really seek a solution to the energy crisis, we must attempt to rationalize future development. The pressures to mine, build upon, and otherwise exploit the nation's lands are mounting and will not wait. ■

Land Subsidence in the

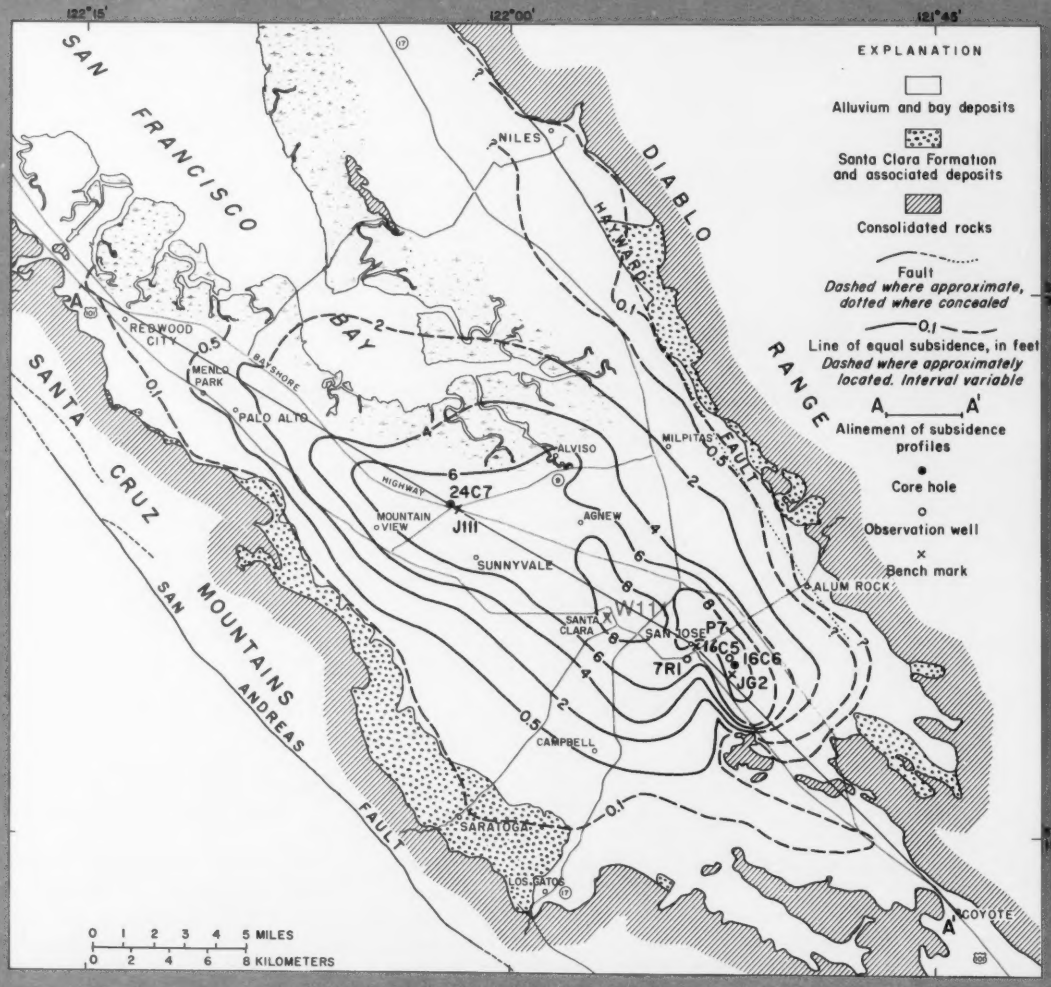


Figure 1. Land subsidence from 1934 to 1967, Santa Clara Valley, California. Compiled from leveling of National Geodetic Survey in 1934 and 1967.

Santa Clara Valley

by **Joseph F. Poland**

Land-surface subsidence due to the withdrawal of fluids by man has become relatively common in the United States in the past 40 years, and has been identified at several other places in the world. In Japan, for example, land subsidence is a surprisingly common feature, having been reported in 40 separate areas—most of which are on low-lying alluvial plains bordering the ocean.

Land subsidence has caused great damage in some areas. Probably the most costly subsidence, worldwide, occurred at the Wilmington oil field in southern California. Subsidence began in 1937 and reached 29 feet at the center of that field by the late 1960s. Much of the subsiding area initially was only five to ten feet above sea level. Because the area is intensively industrialized, extensive remedial measures became necessary to keep the sea from invading the subsiding lands and structures. These remedial measures included massive levees, retaining walls, landfills, repair and maintenance of utility lines and oil wells, and raising of dock structures. The costs for maintaining structures and equipment in operating condition exceeded $100 million by 1962.

Because of the increasing dangers caused by the Wilmington oil-field subsidence, a pilot water-injection operation to repressure the oil zones was started in 1953 and repressuring on a major scale began in 1958. Subsidence of some bench marks was stopped by 1960; by 1969, with the injection of more than a million barrels of water per day into the oil zones, the subsiding area had been reduced from 20 to 3 square miles and locally the land surface had risen as much as one foot.

In other places, subsidence problems are being alleviated in one or more of several ways including: (1) reduction or cessation of withdrawal, generally due to replacement by surface-water imports; and (2) increase of reservoir pressure by artificial recharge at land surface or by water injection through wells.

Because of the intensified withdrawal of ground water and other fluid resources, problems of subsidence are on the increase, both in the United States and worldwide. It is appropriate, therefore, to give a brief statement of principles, and then describe a case history of land subsidence in the Santa Clara Valley of California. This subsidence, the first in the United States to be recognized as caused by groundwater overdraft, has been stopped twice, once largely due to nature's bounty, and once through a water-import program.

Mr. Poland is with the U.S. Geological Survey in Sacramento, California.

In 1925, O. E. Meinzer, of the U.S. Geological Survey, pointed out that when the pressure head in an artesian aquifer is decreased the rock matrix of the aquifer is compressed. Contemporaneously, Karl Terzaghi, the "father of soil mechanics," noted that the cross-bed escape of water which accompanies the adjustment of pore pressures is time-dependent and that attainment of pore-pressure equilibrium in fine-grained beds may take months or years.

Hydrogeologic Setting

The Santa Clara Valley is a long, narrow structural trough that extends about 90 miles southeast from San Francisco, with the Bay occupying much of its northern third. This article focuses on the densely populated central third of the valley, which extends southeastward about 30 miles from Redwood City and Niles to Coyote—about 10 miles southeast of downtown San Jose. As shown in Figure 1, most of this central area experienced one to eight feet of subsidence from 1934 to 1967.

The ground-water reservoir in this central reach of the valley consists principally of alluvium of Quaternary age which ranges from coarse gravel to silt and clay. Near the valley margin coarse-grained deposits predominate. Near the Bay, however, as much as 80 percent is silt and clay. The alluvial aquifer is tapped by many hundreds of productive water wells with depths ranging from 500 to 1,200 feet.

In the central two-thirds of the valley below a depth of about 200 feet ground water is confined under pressure by the overlying fine-grained deposits. This confinement extends northward from the southern part of San Jose to

Palo Alto and Milpitas and beneath the Bay. In most of the confined area, wells more than 200 feet deep flowed in the early years of development. This confined aquifer system is as much as 800 feet thick. Around the valley margins, ground water is unconfined and most of the natural recharge to the ground-water reservoir infiltrates from stream channels crossing the bordering alluvial-fan deposits.

Decline of Artesian Head, 1916-66

In the spring of 1916 the artesian head in index well 7R1 in San Jose (Fig. 1), established in 1912, was resurveyed and found to have subsided nearly 4 feet. Accordingly, a valleywide network of bench-marks was established in 1934, and thenceforth the National Geodetic Survey releveled the networks at intervals, most recently in 1967. During the 33-year period from 1934-67 subsidence ranged from one to four feet under the Bay to eight feet in San Jose. The volume of subsidence (pore-space reduction) in this period was about 500,000 acre-feet.

The subsidence record for bench mark P7 in San Jose is plotted in Figure 2, together with the artesian head in nearby well 7R1. The fluctuation of the artesian head represents the change in stress on the aquifer system. Subsidence is the resulting strain. Subsidence at bench mark P7 (Fig. 1) began about 1918 and reached 5.4 feet by 1938. From 1938 to 1947 subsidence stopped during a period of artesian-head recovery but resumed in 1947, coincident with a rapidly declining head, and, by 1967, had subsided 12.67 feet.

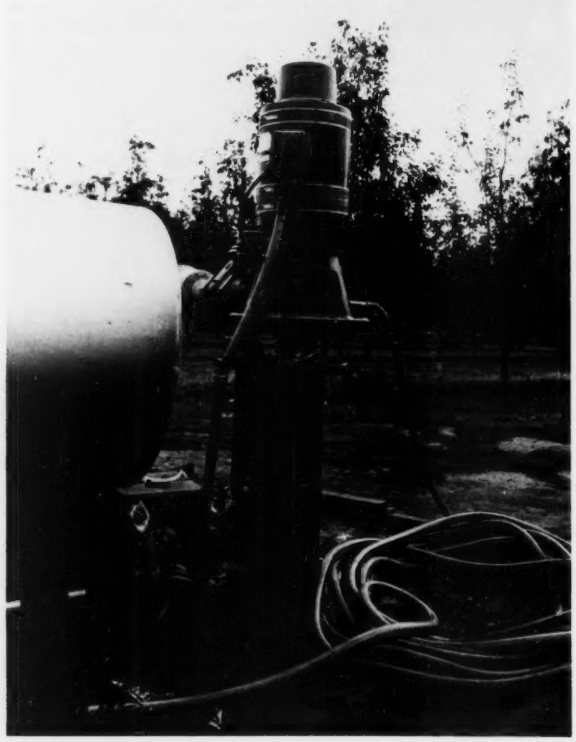
Figure 3 shows land subsidence profiles along line A-A′ from Redwood City to Coyote from 1912 through 1969 (for location, see Fig. 1), using the 1934 leveling as the reference base. The figure shows that prior to 1963, maximum subsidence was occurring in the Sunnyvale area near bench-mark JIII, whereas after this time the area of maximum subsidence shifted to San Jose near bench-mark WIII. Changes in the rate and magnitude of artesian-head decline doubtless have caused such geographic variations in subsidence rate and magnitude with time.

Subsidence Problems

The subsidence has created several major problems. Lands adjacent to San Francisco Bay have sunk two to eight feet since 1912, requiring construction and raising of levees to restrain landward movement of the saline Bay water onto 17 square miles of land now below high-tide level. Also, flood-control levees have been built and maintained near the bayward ends of the depressed stream channels. By 1974 about $9 million had been spent for flood-control levees on the streams entering the Bay to correct for subsidence effects, according to Lloyd Fowler, Chief Engineer, Santa Clara Valley Water District. In addition, a major salt company has spent a substantial amount of money maintaining levees on 30 square miles of salt ponds and the landward chain of dikes to counter as much as eight feet of subsidence. Several hundred water-well casings have been ruptured by the compaction of the sediments. The cost of repair or replacement of such damaged wells reportedly has been $4 million. Including funds spent on maintaining the salt-pond levees, establishing and releveling the bench-mark network, repairing railroads, roads, and bridges, and making private engineering surveys, the gross costs of subsidence are in the range of $15-20 million to date.

Local agencies have been working since the 1930s to conserve and obtain water supplies adequate to stop the ground-water overdraft and raise the artesian head. Their program has involved: (1) salvage of flood waters from local streams that would otherwise waste to the Bay and

This well, in Lake County, California, shows the effects of a total land subsidence of about 3 feet over the last 30 years.



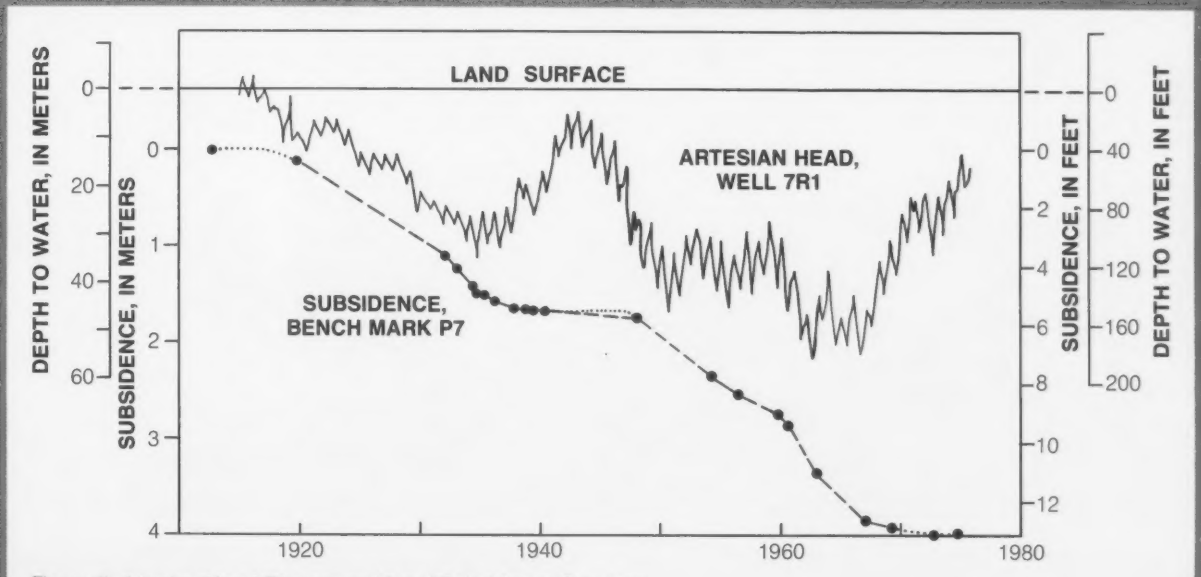


Figure 2. Artesian-Head Change and Land Subsidence, San Jose

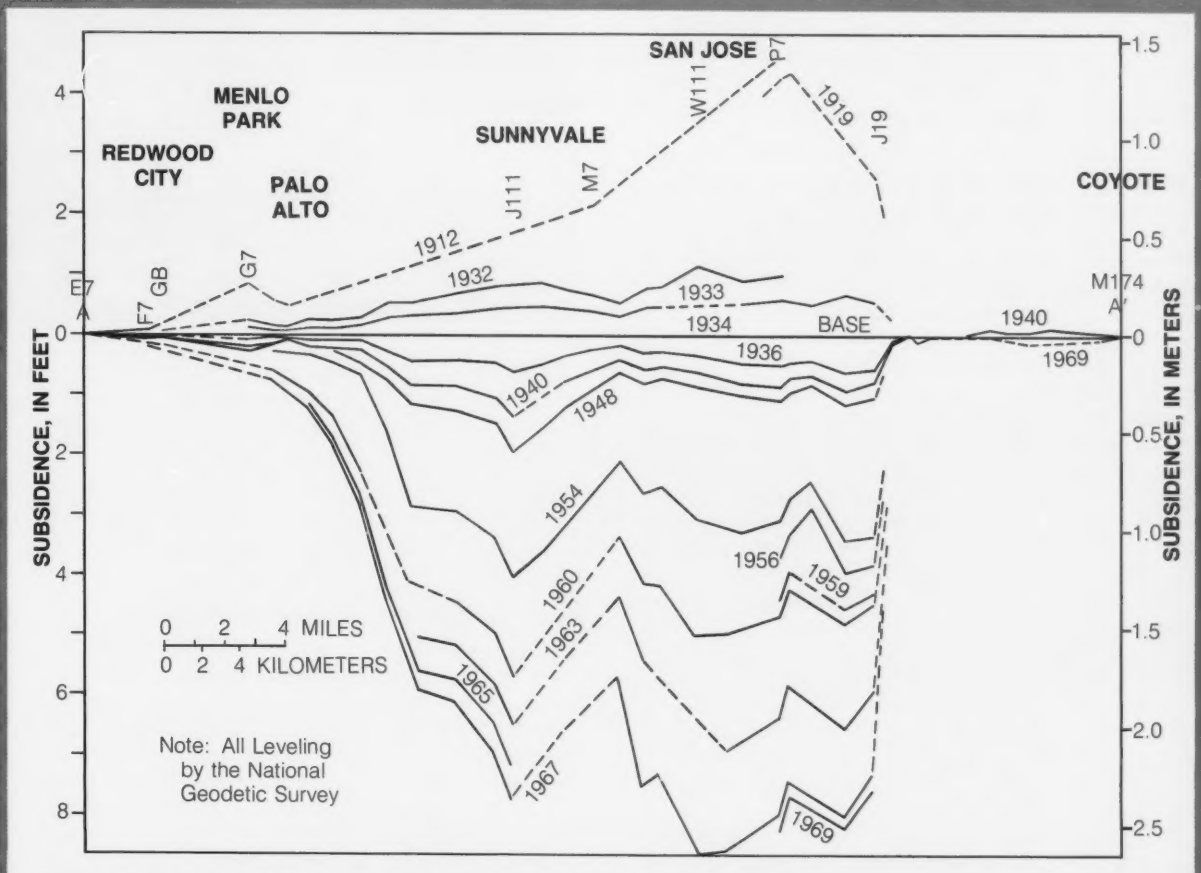


Figure 3. Profiles of Land Subsidence, Redwood City to Coyote, Calif. 1912-69.

(2) importation of water from outside the valley. In 1935-36, five storage dams were built on local streams to provide detention reservoirs with a combined storage capacity of about 50,000 acre-feet in order to retain flood waters and permit controlled releases to increase streambed percolation (Hunt, 1940). According to the California State Water Resources Board, the storage capacity of detention reservoirs was increased to 144,000 acre-feet by the early 1950s.

Recovery of Artesian Head, 1967-75

The recovery of water level since 1967 has been dramatic. By 1975, the spring high water level at index well 7R1 (Fig. 4) was 104 feet above that of 1967, and about equal to the level in this well in 1925. This major recovery of artesian head was due to several factors, including increased water imports, favorable local water supply, decreased pumpage, and increased recharge (Fig. 4). The most important factor was the increase of imports.

The import of surface water to Santa Clara County began about 1940 when San Francisco began selling water, imported from the Sierra Nevada, to several municipalities. This import increased to 44,000 acre-feet by 1975 (see blank segments of yearly bars, upper right graph, Fig. 4). Surface water imported from the Central Valley through the state's South Bay Aqueduct first became available in 1965, and, by 1974-75, the Aqueduct import was 104,000 acre-feet (see cross-hatched plus diagonally-ruled segments of yearly bars, upper right graph, Fig. 4). Total imports to Santa Clara County increased fivefold from 1964-65 to 1974-75—from 30,000 to 148,000 acre-feet per year. The average yearly pumpage of ground water, which had reached its peak of 185,000 acre-feet in 1960-65, decreased to 150,000 acre-feet in 1970-75. A principal reason for this 19 percent decrease is the tax on ground-water pumpage applied since 1964 for water extracted from the ground-water basin.

Recharge from stream channels and percolation ponds to the ground-water reservoir has been augmented since 1965 by water from the South Bay Aqueduct that could not be used directly. The yearly quantity diverted to recharge

Photo shows the South Bay Yacht Club in Santa Clara County, California, on opening day in 1914. Insert depicts the same area in 1975, showing levee buildup due to land subsidence in the intervening years. (Courtesy of Santa Clara Valley Water District)

areas (crosshatched segment of yearly bars, upper right graph, Fig. 4) in the 10 years has averaged 41,000 acre-feet and represents 56 percent of the total import from the South Bay Aqueduct.

Extensometers to Measure Compaction

Extensometers (compaction recorders) were installed by the U.S. Geological Survey in 1960 in two 1,000-foot cased core holes at the centers of subsidence: 16C6 in San Jose and 24C7 in Sunnyvale (Fig. 1). They have recorded compaction of the confined aquifer system for 18 years. Diagrams of the two types of extensometers are shown in Fig. 5. Records from these instruments show that the compaction measured to a depth of 1,000 feet—nearly the maximum depth of water wells—is about equal to the land subsidence as measured periodically by levelling of the bench-mark network.

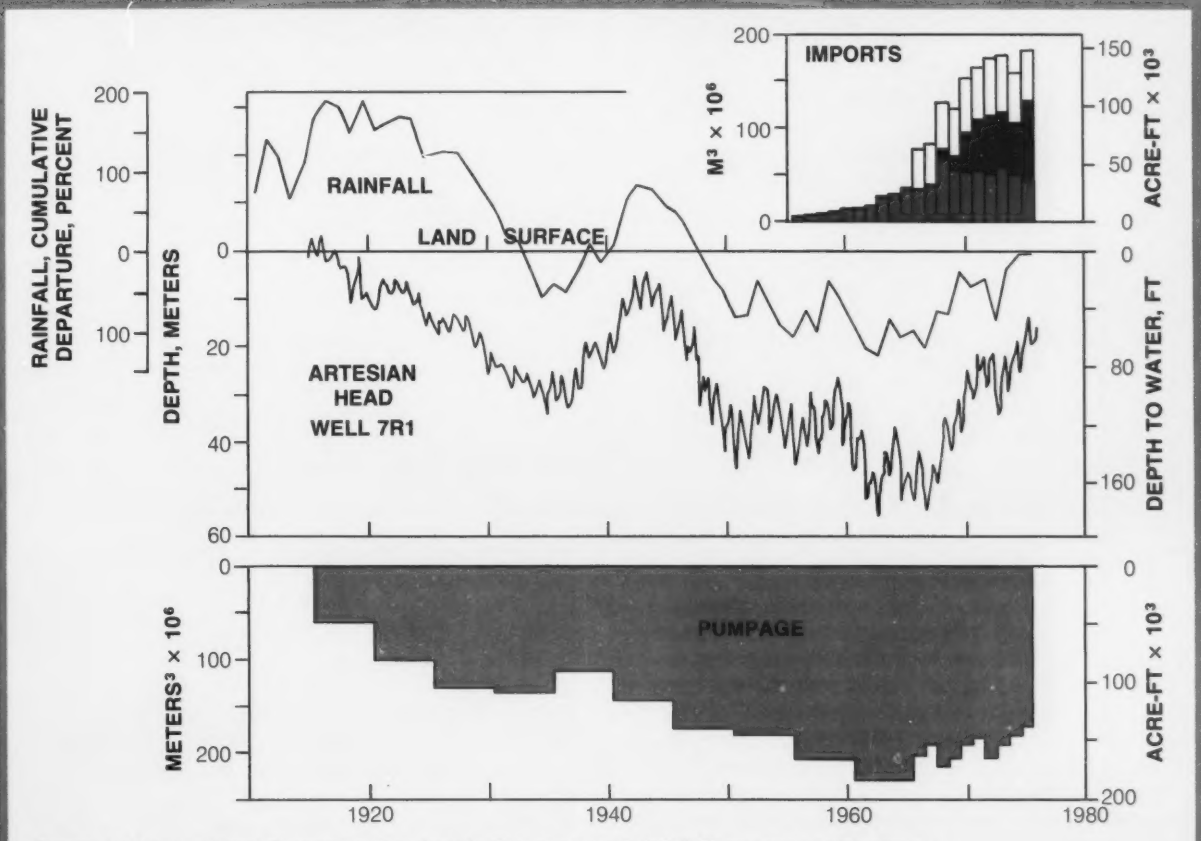


Figure 4. Artesian-Head Change in San Jose in Response to Rainfall, Pumpage, and Imports.

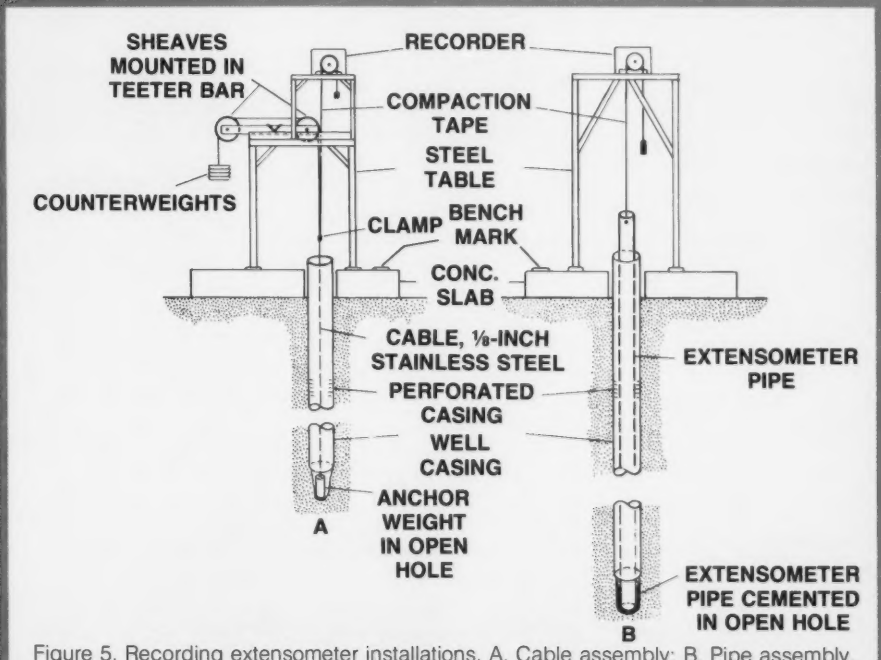


Figure 5. Recording extensometer installations. A, Cable assembly; B, Pipe assembly.

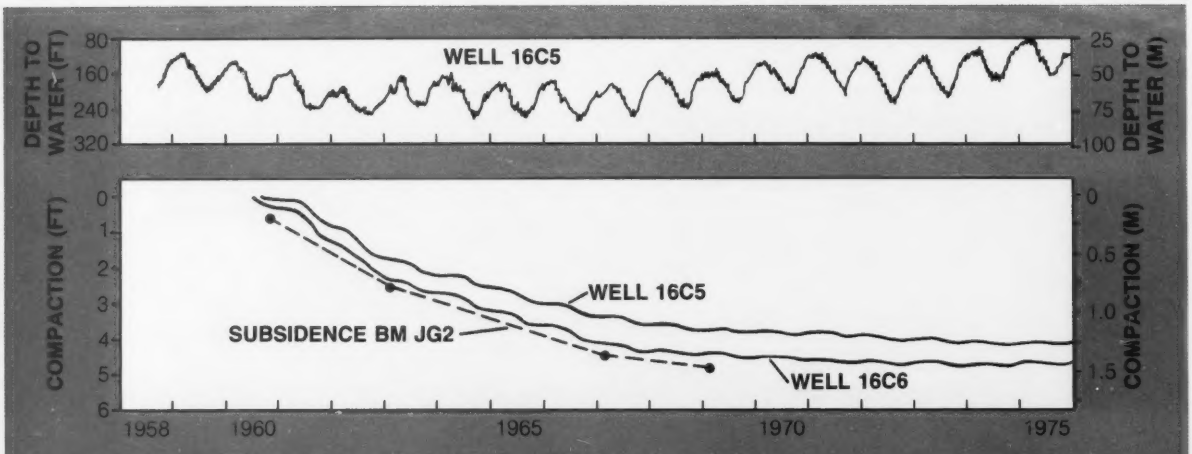


Figure 6. Measured water-level change, compaction, and subsidence in San Jose.

Figure 6 is a time plot of the measured compaction in the 1,000-foot San Jose well 16C6 and the compaction and artesian-head fluctuation (change in applied stress) in adjacent unused well 16C5 through 1975; Figure 6 also shows the subsidence of adjacent bench mark JG2 from 1960 to 1969. Measured compaction of the confined aquifer system to the 1,000-foot depth from July 1, 1960, to December 31, 1975, was 4.7 feet. The rapid decline of artesian head from 1959 to 1962 caused rapid compaction of the aquifer system in those years but the rate decreased during the period of relatively steady head from 1962 to 1967. From 1967 to 1975, the artesian head recovered about 100 feet at well C5.

The marked decrease in rate of subsidence in response to the dramatic head recovery since 1967 is demonstrated graphically by the compaction records from the two deep extensometers in San Jose and Sunnyvale (Fig. 7). The rate of compaction in well 16C6, in San Jose, decreased from about one foot per year in 1961 to 0.24 feet in 1967 and to 0.01 in 1973. Net expansion (land-surface rebound) of 0.02 feet occurred in 1974. In Sunnyvale, compaction of the sediments above the 1,000-foot anchor in well 24C7 decreased from about 0.5 feet per year in 1961 to 0.04 in 1973; net expansion of 0.016 and 0.04 occurred in 1974 and 1975, respectively.

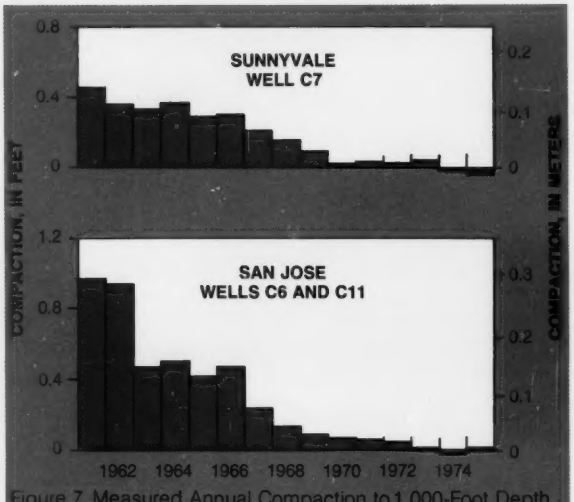


Figure 7. Measured Annual Compaction to 1,000-Foot Depth.

Both the cause of land subsidence and the means of its control are known. The evidence given here and in other studies by the Geological Survey demonstrates that for this type of subsidence, which is caused by the decline of the artesian head, most of the compaction occurs in the fine-grained clayey beds (aquitards) that are the most compressible but have low permeability. Water escapes slowly from these beds, and thus their compaction occurs slowly, but the ultimate compaction is large and chiefly permanent.

The subsidence in the Santa Clara Valley of California has been stopped by raising the artesian head in the aquifers until it equaled or exceeded the maximum pore pressures in the aquitards. The compaction and water-level records being obtained by the Geological Survey indicate that if the artesian head can be maintained 10 to 20 feet above the levels of 1971-73, subsidence will not recur. On the other hand, subsidence will recommence if the artesian head is drawn down as much as 20 to 30 feet below the 1971-73 levels. ■

Planning for Discourse

by **David E. Wojick**

Unstructured discourse involves considerable waste and breeds confusion. We routinely use only about 10 percent of the ideas presented in any group discussion because the logical structure of discourse is too complex. In any series of meetings, redundancy may be as high as 60 to 80 percent by the third session. Misunderstandings and conceptual confusions arise, often because not enough questions are asked or examples given.

Planning the use of natural resources depends on the quality of discourse that preceeds it, and in recent years, where public policy and public meetings are involved, the discourse has widened to involve more people, more viewpoints, more perspectives. The quality of discourse has never been more important.

While we all sense the difference between a good meeting and an unproductive one, it is only recently that a method has been developed to define that difference and help assure that meetings are good ones. The method, using the technique of issue analysis, rates the quality of a discourse by means of 17 related analyses. Using these measures, researchers have discovered how the format, conduct, type and number of participants, and other characteristics of a meeting influence the quality of the resulting discourse.

People planning a meeting—whether a gathering of three experts or a full public meeting with dozens participating—can move the discourse along paths that yield the most productive group thinking. Using issue analysis in meetings can facilitate more sophisticated deliberation. The technique has broad application: executive policy-making, project management, social or economic impact analysis, public hearings, technical conferences, and even the classroom. The list is endless; the application, universal.

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Managing Discourse

The idea behind issue analysis is that complex reasoning—that is, reasoning that requires more than a few hours of effort—always involves identifying and following out many lines of thought. Like explorers in a river basin, participants in discussion must search out a great number of tributary ideas before a discourse is completed. Moreover, to push this analogy a little, one often cannot tell when standing at a fork just which branches are most important, so, as anyone who has participated in much group interaction knows, you spend a lot of time in the swamps.

Issue analysis as a discourse management tool is designed to help you get out of the swamps. It does this by providing a map of the developing lines of thought so that when thinking gives out on one line it is possible to "go over the ridge" and pick up another. The map, to switch metaphors, is known as an "issue tree.*"

If a group watches and uses the developing tree of its own ideas during a discussion, it can sustain hours or even days of reasoning on a single topic. It is also possible to bring people into the middle of a piece of reasoning and let them grasp, by looking at the tree, what has so far been explored. It is even possible to stop a discussion for a month and pick it up again with all the reasoning intact. This use of an issue tree to allocate attention efficiently is called "interactive issue analysis."

When an issue as large as the impact of a public works project must be worked out in detail, many months of complex reasoning are required. Often many disciplines, interest groups, contractors, and publics are involved in identifying and working out likely impacts and in formulating alternative issues and decision options.

The task of managing this reasoning so as to be comprehensive and thorough, while avoiding waste, is enormous. Using issue trees, researchers have roughly quantified various features of pieces of discourse, such as

*For detailed discussion of issue trees, see Water Spectrum, Winter 1975-6.

the amount of redundancy, time spent in disgressions, relative attention given to various issues, thoroughness, and depth. Findings from this research suggest the magnitude of the problem of efficient management of complex discourse. For example:

☐ Researchers often choose to analyze discourse to a level of detail at which people are making 100 to 150 points per hour. At this level, in an open discussion, the number of points made in response to a preceeding point (the rate of branching on the issue tree) typically averages about 1.2. When a group develops an issue tree interactively, the average increases to between 4.0 and 5.0 branches per point. This means that in a typical free discussion fewer than one third of the major lines of thought are identified.

☐ My colleagues and I once tracked a committee which met three times, at intervals of one month, to formulate a policy. Because of the long time span, a lot of reasoning had to be repeated just to get to new points. The second meeting saw a 50 percent redundancy rate, while in the third meeting only 15 percent of the points made were new; 85 percent were redundant. Most of this redundancy was simply waste—waste of time and waste of valuable human resources, caused by the complexity of discourse.

Efficiency, comprehensiveness and thoroughness are the management goals of any discourse. The complexity of the reasoning which must go into any good discourse makes these goals hard to achieve.

Taxonomies, agendas, checklists and other tools are often used to try to simplify the reasoning, sometimes to good effect. But another approach, which in the long run we must all adopt, is to learn to manage the complexity itself. This "discourse management" is what issue analysis tries to facilitate, simply by keeping track of the lines of thought.

The problem of discourse management is that until now there has been no way except intuition to break down an issue into discrete units which can be dealt with individually. As a result, attention either jumps back and forth, or settles on one or two issues. Issue analysis continuously refines the issues into discrete units, heirarchically arranged, so that attention can be systematically allocated. In this way, important considerations are not overlooked, and each issue receives proper attention.

Let's construct a hypothetical discussion and then subject it to issue analysis, first mapping the branching of the discourse on an issue tree, then rating the discussion using various measures. Figure 1 summarizes the actual points made in the discussion and the order of points. Figure 2 indicates the type of point made. Each of the four speakers is color-coded for clarity.

Group Size

As simple a factor as group size has a profound impact upon the quality of discourse. Almost everyone enjoys conversation, but as the number of persons involved approaches five or six, difficulties arise. Some people stop talking, others talk too much, and there is a struggle for attention. By the time the group grows to ten, the need for discourse management becomes critical. Expand this number to fifteen, and few people will be able to make their points unless a formal leader is chosen and a clear agenda acknowledged. Beyond thirty persons it is simply impossible for more than a fraction to speak at all. Careful planning and a full battery of management techniques are required if useful communication is to occur.

Discourse requires tracing out lines of thought in a complex hierarchical array; that is, it requires traversing the issue tree. Because no two people will follow the same lines on a given issue, as the number of participants increases, the problem of obtaining a coherent discussion increases dramatically. This is where discourse

Issue analysis technique shows how the nature of a meeting—size, diversity of opinion, participants' expertise, and other factors—affects the quality of discourse.

management comes in. Good management is the execution of a good plan, without which any discourse will become chaotic. If more than half dozen people are involved each pulls the thinking in his own direction. Good planning means recognizing the problems, understanding the alternatives and choosing wisely. Tables 1-3 are designed to facilitate good planning and management of discourse by making clear how various process features will effect discourse. Once these effects are understood, it becomes possible to anticipate problems and to formulate alternative strategies, in the form of alternative processes, to overcome these problems.

In a small group everyone talks some; speeches are short and the climate is personal. Inefficiencies such as digressions will be tolerated, as will two-person dialogues. Thus, brevity, depth, interchange and participation will be high, as will Q-, O-, and E-rates; but tan-avoid and dig-avoid will be low (*see Table 1*). Because issues will be discussed until understood, red-avoid will be high, but balance low. Because the number of perspectives is limited, thoroughness and bias-avoid will be low.

All in all, accuracy will be easy to maintain, hence high; efficiency, low; and effectiveness, only medium, because of the efficiency, balance and bias problems. It is unclear what effect, if any, group size has on earnestness.

As group size increases, the discourse feature values gradually change to their opposites, except for thoroughness, tan-avoid, dig-avoid, and the general discourse features of efficiency and effectiveness. Thoroughness reaches its peak with a medium-sized group and then drops off as increasing group size leads to speechmaking. Speechmaking occurs because in a large group one can never be sure of getting the floor again, so one attempts to say everything at once. This is why participation, depth, brevity, interchange, and the Q-, O-, and E-rates all drop off as group size increases. Increasing group size also generates strong peer pressure against tangents and digressions, so both drop off. But tangents, which are subtler than digressions, return with speechmaking in the form of too much detail.

Table 1. Effects of Group Size on Discourse

	Group Size		
	2-10	10-30	over 30
Participation	H	M	L
Depth	H	M	L
Thoroughness	L	H	L
Brevity	H	M	L
Red-avoid	H	M	L
Tan-avoid	L	H	L
Interchange	H	M	L
Balance	L	M	H
Q-rate	H	M	L
O-rate	H	M	L
E-rate	H	M	L
Dig-avoid	L	H	H
Bias-avoid	L	M	H
Accuracy	H	M	L
Effectiveness	M	H	L
Earnestness	—unknown, if any—		
Efficiency	L	H	L

L=low M=medium H=high

Speechmaking, together with the general reduction of discourse feature values, causes both efficiency and effectiveness to drop off for truly large groups. Only balance, dig-avoid, and bias-avoid improve steadily with increasing group size.

Level of Expertise

Public participation in policy and decision making entails experts and laymen interacting. While the notion of public participation was originally based upon considerations of democratic process, experience suggests that there are also good practical reasons for it.

Building consensus is one of these reasons, and many participation processes are justified on this basis. But beyond the consensus building, public participation processes yield valuable insights—sometimes even vital ones—into the secondary consequences of a proposed

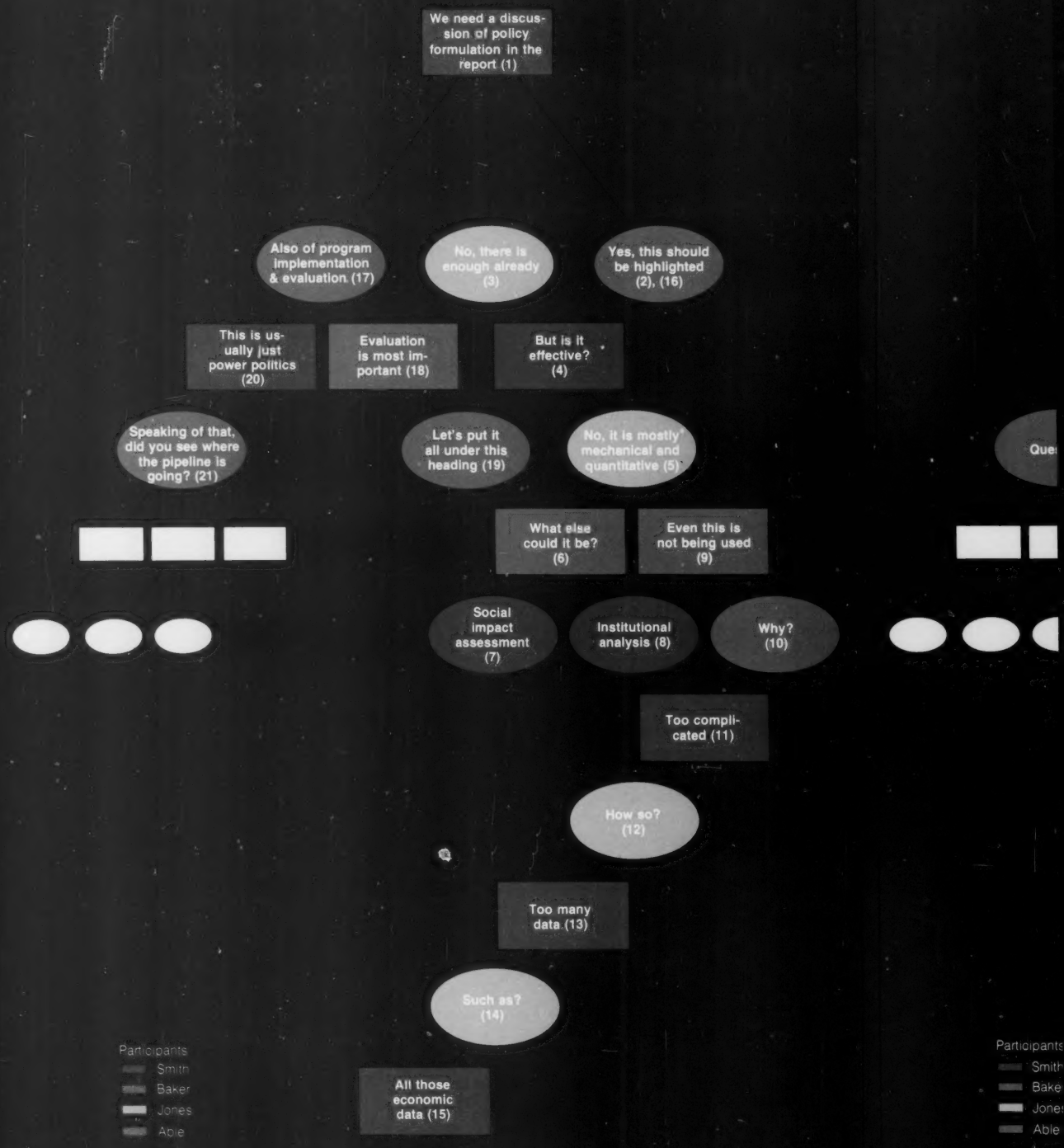
We need a discussion of policy formulation in the report (1)
Also of program implementation & evaluation (17)
No, there is enough already (3)
Yes, this should be highlighted (2), (16)
This is usually just power politics (20)
Evaluation is most important (18)
But is it effective? (4)
Speaking of that, did you see where the pipeline is going? (21)
Let's put it all under this heading (19)
No, it is mostly mechanical and quantitative (5)
What else could it be? (6)
Even this is not being used (9)
Social impact assessment (7)
Institutional analysis (8)
Why? (10)
Too complicated (11)
How so? (12)
Too many data (13)
Such as? (14)
All those economic data (15)
Participants
Smith
Baker
Jones
Able

Figure 1. Issue Tree of Hypothetical Discussion—What Was Said and in What Order.

Figure 2. Issue Tree of Hypothetical Discussion—Kinds of Points Made

Analyzing the Discussion

How does this conversation rate? Here is an analysis using the issue trees shown in Figures 1 and 2.

1. **Participation.** There are 21 points made, an average of 5.25 per person. Participation varies from 8 points made by Smith to 3 by Baker, a wide range. Smith dominated the conversation.
2. **Depth**=sum of points on all branches ÷ number of branches=32/6=5.33. This measure, which suggests the level of detail of the discussion, is on the low side of the typical range. Note that some points are counted more than once.
3. **Thoroughness** (branch rate)=number of branches ÷ number of occurrences of branching=19/14=1.36. This is typical.
4. **Brevity**=number of points made ÷ number of speeches=21/19=1.11. This is very high; Smith's points 7 and 8 and Able's 18 and 19 are the only instances of more than one point made in a speech.
5. **Redundancy-avoidance** (red-avoid)=number of new points ÷ total number of points=20/21=0.95. This is very high; only Able's points 2 and 16 are redundant.
6. **Tangent-avoidance** (tan-avoid)=number of non-tangential points ÷ total number of points=14/21=0.67.
7. **Interchange.** Poor: Jones responds only to Smith; Smith never responds to Able.
8. **Balance** (evenness of the distribution of branching). Poor, due to disgression at point 21 and tangent beginning at point 9.
9. **Question-rate** (Q-rate)=number of questions ÷ number of new points=6/20=0.30, which is a little high. In fact, both the tangent and the digression are driven by questions. Note that redundant points are not counted in Q-, O-, and E-rates.
10. **Objection-rate** (O-rate)=number of objections ÷ number of new points=3/20=0.15. The O-rate indicates the spread of opinion, which here is fairly broad. The objections are weakly placed, however; one (point 9) starts a tangent and another (point 20) elicits a digression.
11. **Example-rate** (E-rate)=number of examples ÷ number of new points=3/20=0.15. This is good. Note how the examples help to keep things clear. The E-rate suggests how abstract the discussion is.
12. **Digression-avoidance** (dig-avoid)=number of branches ÷ total number of points, including digression points=19/26=0.73, a rating in the fair range. This is the only measure in which digression points (following point 21) are counted.

This example is too small for any assessment of the five other measures. They are defined below:

13. **Bias-avoidance** (bias-avoid). Are all types of questions—how, why, what then, etc.—being answered? Is too much attention being allocated to one kind of question, at the expense of others?
14. **Accuracy.** Have the issues which were to be addressed in fact been addressed?
15. **Effectiveness.** How well were issues addressed, regardless of whether they were intended to receive attention?
16. **Earnestness.** How sincerely are the participants' opinions and feelings being expressed?
17. **Efficiency**=number of useful points ÷ total number of points. In this example, efficiency looks low, due to the tangent and the digression.

action. A participation process is a kind of sampling procedure which, while it may not be as rigorous as a professional poll, is more flexible and searching. Like government, industry is coming to realize the benefit of secondary impact analysis through participation in planning by those most likely to be affected.

While mixing experts and non-experts is good planning policy, there are marked trade-offs among various discourse features when mixed and non-mixed groups are compared. Thus, whether a given group convened for a given reason should be mixed is a major decision in discourse planning, and planning a good mixed session is not a simple matter.

Experts, because they know more and are practiced in talking about the issues, talk longer than non-experts, and with less interchange and redundancy (*see Table 2*). Because they will all talk, participation and depth are high, but so is digression. They know how to object and do so often, leading to many tangents and bias toward technical issues. Thus, efficiency is low for a group of experts, but because they share a common interpretation of the issues, accuracy remains high.

The strengths of a non-expert group are brevity, tan-avoid, and high E-rates, all of which stem from a greater need for clarity. In addition, the shared non-expert orientation fosters participation and accuracy just as the shared expert orientation does for the experts. All in all, the non-expert group is the most efficient, but, because of its lack of knowledge, it is least effective.

When the experts and non-experts are mixed, the discourse feature values shift to reflect the features of discourse between diverse perspectives. Participation is low because some non-experts are cowed and some experts are bored. Nonetheless, "perspective swapping" yields thoroughness, brevity, much interchange and a high Q-rate. Balance is good and bias avoided, but the need to state important points in two different ways results in redundancy and a low E-rate. Two perspectives make accuracy difficult and efficiency only moderate, but produce the most effective final product. Whether level of expertise has any effect upon earnestness is unknown.

Table 2. Effects of Level of Expertise on Discourse

	Type of Group		
	Non-expert	Mixed	Expert
Participation	H	L	H
Depth	L	M	H
Thoroughness	L	H	M
Brevity	H	H	L
Red-avoid	M	L	H
Tan-avoid	H	H	L
Interchange	M	H	L
Balance	M	H	L
Q-rate	L	H	M
O-rate	L	M	H
E-rate	H	L	M
Dig-avoid	M	H	L
Bias-avoid	M	H	L
Accuracy	H	L	H
Effectiveness	L	H	M
Earnestness	—unknown, if any—		
Efficiency	H	M	L

L=low M=medium H=high

Spread of Perspective

A variety of perspectives is essential to a good public participation product, but it produces special problems for the discourse planner. Different opinions in a group may mean that participants talk through one another. Working agreement, even on goals, may not be obtainable. Discourse tends to degenerate into sloganeering, and the potential for total breakdown is always present.

Under these circumstances it is no wonder that many planners shy away from bringing truly diverse perspectives together. Yet, if the difficulties can be anticipated and overcome, bringing polarized points of view to bear on an issue is by far the most productive way to address it. Table

3 shows that the best way to handle diverse perspectives, if high effectiveness is the goal, is to get a spread of perspectives rather than just polar opposites. Unfortunately, there are, as always, complex trade-offs among alternative process features, so the planner must carefully consider what is wanted.

Finding they share perspectives makes people comfortable, which in turn makes for good participation, brevity and interchange. Examples can be used to convey principles and concepts, so the E-rate is high. Unfortunately, agreement also leads to redundancy, tangents, poor balance, low Q- and O-rates, digression and bias.

A single perspective yields a sense of complacency, which is reinforced by repeating certain accepted phrases. We have seen cases where several such slogans were each repeated a dozen times per hour, and, as a result, red-avoid was very low. This sense of complacency makes earnestness difficult to sustain and encourages tangents and digressions. The simple fact of general agreement lowers the Q- and O-rates, and depth and bias lead discussion into familiar channels.

Introduction of a second perspective, the polar opposite of the first, dramatically alters many of the discourse features. Now everyone is in gunfight stance, wary and ready to disagree with even small heresies, lest they be led to admit great ones. Now participation, brevity and thoroughness are low; depth and the O-rate are high as disagreements are pursued at length. Speechmaking becomes common, and the very slogans which served as commonplaces for a one-perspective group become rallying cries in the polarized setting—joined by the slogans of attack. Thus, red-avoid is low and so is interchange. Lack of common perspective makes the E-rate low and reduces accuracy. The focus of attention upon differences makes for low bias-avoid. On the other hand, the seriousness of the interest serves to minimize digressions and tangents.

Table 3. Effect of Spread of Perspectives on Discourse

	Range of Perspectives		
	Narrow	Wide	
		Spectrum	Polar
Participation	H	M	L
Depth	L	M	H
Thoroughness	M	H	L
Brevity	H	M	L
Red-avoid	L	H	L
Tan-avoid	L	L	L
Interchange	H	M	L
Balance	L	H	L
Q-rate	L	H	M
O-rate	L	M	H
E-rate	H	M	L
Dig-avoid	L	H	H
Bias-avoid	L	H	L
Accuracy	H	L	M
Effectiveness	L	H	M
Earnestness	L	M	H
Efficiency	L	H	M

L=low M=medium H=high

All in all, polar perspectives yield higher efficiency and effectiveness, and much higher earnestness, than will a single perspective. But if efficiency and effectiveness are the goal, then a spread of perspectives is usually best.

A spread of perspectives reduces the sense of conflict, even though it includes polar opposites, because these extremes do not get consistent support. Slogans no longer serve, and efforts shift from pursuing objections toward clarification of issues. Thus thoroughness, balance, and the Q-rate are all high. Bias is low because a wide range of perspectives comes into play. Pressure mounts, however, for tangential pursuit of the varying shades of opinion. As in the polar situation, digressions are suppressed by the sense of serious disagreement. The spectrum of perspectives contributes a new sort of redundancy—saying the same thing many ways—but, by eliminating the almost endless repetition of points which characterizes polar debate, redundancy as a whole is greatly reduced.

Accuracy is low because a spectrum of perspectives makes it hard to keep a goal clearly in view. But both efficiency and effectiveness are increased by the interplay of many opinions.

Issue Analysis and Logic

Logic is the science of reasoning, and our observations about group reasoning are part of applied logic. Historically, logic as a discipline has concentrated for the most part upon the activity of drawing conclusions, called "inference."

Inference has to do with drawing conclusions from evidence or premises. Although an integral part of reasoning, inference is far from being the whole of reasoning. Asking questions, raising objections, clarifying meanings, giving examples—each of these activities is a vital part of good reasoning in its broadest sense.

Issue analysis attempts to provide a framework wherein a general theory or science of human reasoning becomes possible. It is an infant science, of course, and its form is far from clear. But it is clear already that this science has the power to reveal a great deal about reasoning which heretofore has been unknown and unsuspected. The fact that all reasoning has an underlying tree-like structure composed of discrete elements opens the door to a host of new investigations and techniques for improving reasoning. The measures and features of group reasoning discussed here are just a starting point.

There are very few human activities which do not involve reasoning. For this reason logic, before it became a branch of pure mathematics, was considered an essential part of any education. Perhaps it can be so again. ■

Artificial Reefs

by **Richard B. Stone**

South Carolina fishermen in the early 1800s noted that catches of sheepshead were declining steadily as the forests on the barrier islands were cut down and the land cleared to cultivate sea-island cotton. Formerly, these fish had been taken in large numbers around trees which had fallen into the waters along the gradually eroding banks of the islands. The trees became covered with barnacles and other forms of marine growth and provided food and shelter for the sheepshead. As the trees disappeared, so did the sheepshead.

The South Carolina fishermen were not the first to recognize that irregular bottom protuberances, such as submerged trees, reefs, rocks and shipwrecks, are good places to fish. That has been common knowledge among anglers for centuries. But they were among the first to try correcting the situation when catches declined. They built structures that resembled huts without roofs—out of oak or pine logs—and floated them to the areas where they had previously caught the sheepshead. The structures were then sunk by filling them with stones or live oak timber. Within weeks, as the barnacles and other growth formed, the sheeps-

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A french angelfish feeds on encrusting growth on tires that form an artificial reef. Wes Pratt.

head returned and the anglers again began making good catches.

Although recreational fishermen have become much more mobile in recent years thanks to fast, seaworthy boats and can avoid, to a certain extent, rather barren or depleted fishing grounds inshore by travelling farther out from shore, they still have problems in common with the early South Carolina fishermen. The increasing demands on stocks of fish by both commercial and recreational fishermen and losses of estuarine and inshore rough bottom habitat through development and pollution have had substantial local impact on the availability of many important species such as reef dwelling snappers and groupers. Off many of the coastal states, anglers have to go 20 to 40 miles to find extensive areas of rock outcroppings and the associated concentrations of fish. These conditions have prompted most of the coastal states and many sport fishing organizations to find a solution similar to that used by the South Carolina sheepshead fishermen—the construction of artificial reefs. Probably close to 500 reefs have been built off the U.S. coasts in the past 40 years.

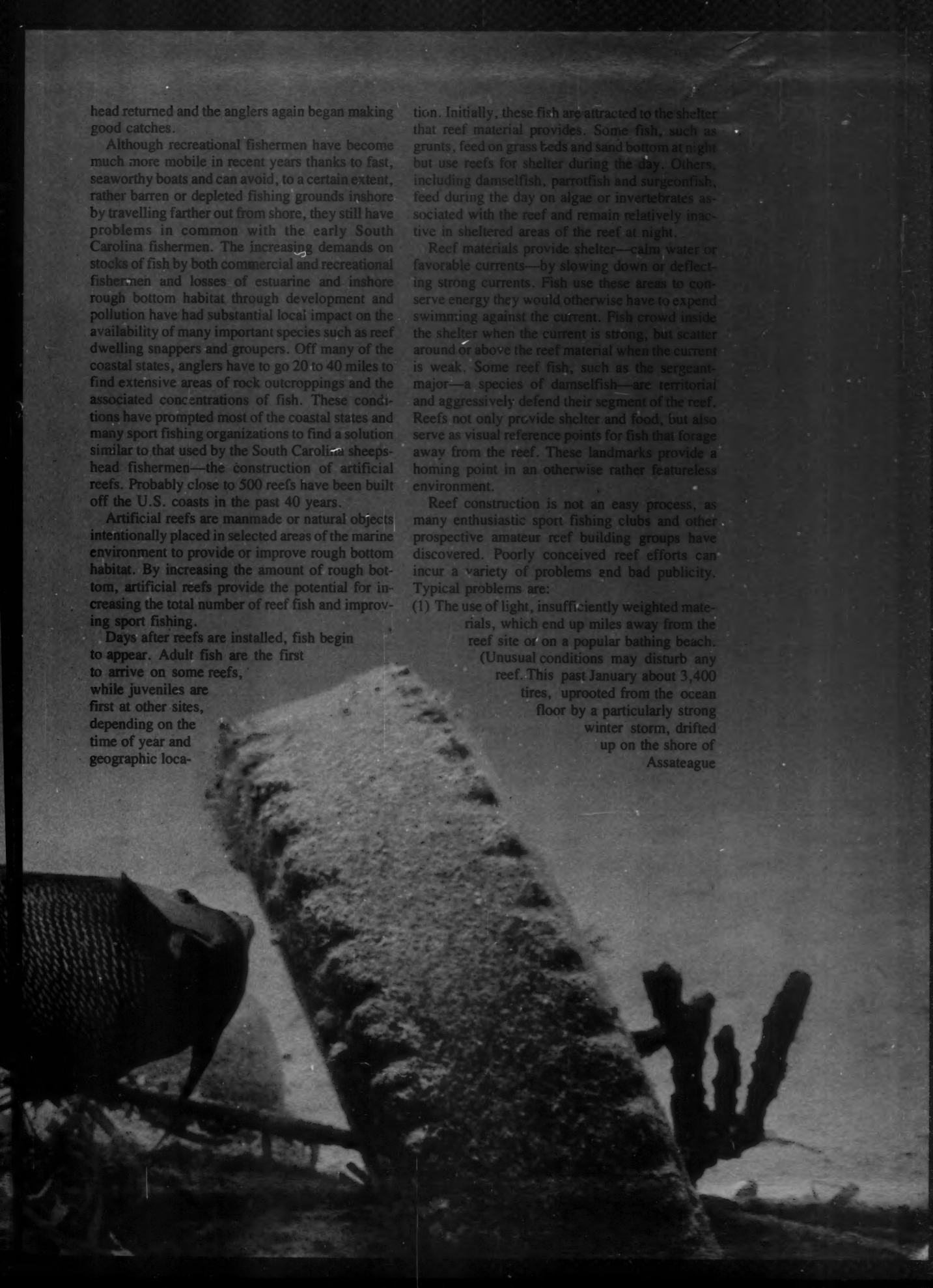
Artificial reefs are manmade or natural objects intentionally placed in selected areas of the marine environment to provide or improve rough bottom habitat. By increasing the amount of rough bottom, artificial reefs provide the potential for increasing the total number of reef fish and improving sport fishing.

Days after reefs are installed, fish begin to appear. Adult fish are the first to arrive on some reefs, while juveniles are first at other sites, depending on the time of year and geographic location. Initially, these fish are attracted to the shelter that reef material provides. Some fish, such as grunts, feed on grass beds and sand bottom at night but use reefs for shelter during the day. Others, including damselfish, parrotfish and surgeonfish, feed during the day on algae or invertebrates associated with the reef and remain relatively inactive in sheltered areas of the reef at night.

Reef materials provide shelter—calm water or favorable currents—by slowing down or deflecting strong currents. Fish use these areas to conserve energy they would otherwise have to expend swimming against the current. Fish crowd inside the shelter when the current is strong, but scatter around or above the reef material when the current is weak. Some reef fish, such as the sergeant-major—a species of damselfish—are territorial and aggressively defend their segment of the reef. Reefs not only provide shelter and food, but also serve as visual reference points for fish that forage away from the reef. These landmarks provide a homing point in an otherwise rather featureless environment.

Reef construction is not an easy process, as many enthusiastic sport fishing clubs and other prospective amateur reef building groups have discovered. Poorly conceived reef efforts can incur a variety of problems and bad publicity. Typical problems are:

(1) The use of light, insufficiently weighted materials, which end up miles away from the reef site or on a popular bathing beach. (Unusual conditions may disturb any reef. This past January about 3,400 tires, uprooted from the ocean floor by a particularly strong winter storm, drifted up on the shore of Assateague



Wes Pratt

Island, Maryland.) Shifting artificial reef material also can play havoc with a commercial fisherman's bottom trawl. The proper selection and preparation of reef material will insure no movement once it is on the bottom.

(2) Inadequate buoys and buoy chains, which result in loss of the buoys—and the reef. A reef without buoys can be very difficult to find even with sophisticated electronic devices.

Also, reefs must be placed so they will not conflict with other uses of the marine environment such as commercial fishing, shipping, or mineral development. Another requirement is the use of nontoxic materials that will not pollute the aquatic environment. These are reasons that habitat enhancement with artifical reefs should be managed by qualified individuals with adequate financial support.

Many of the artificial reefs that have been constructed over the last 40 years have been initiated by the enthusiasm of a relatively small number of people in a local area. With publicity, this enthusiasm soon spreads. People start to donate materials, and offers of barges and boats to transport materials to the reef site are usually forthcoming. As much material as can be handled by several barges in one or two trips is gathered at a staging area, then loaded on the barges, and finally, with newspaper reporters and spectators looking on, the materials are towed offshore and dropped on an authorized reef site. However, in many cases this constitutes the entire reef-building effort. Perhaps the reef is buoyed and for some months fishing is excellent. Often, though, in many of the early efforts, there was no attempt made to add additional materials and expand the reef. The buoys, if not maintained properly, were lost during storms or torn from their moorings by the anchor of a fishing boat. Then only the larger fishing boats with more elaborate gear stood a chance of locating the reef. The smaller boats, unable to find the manmade 'fishin' hole,' went back to the old stand-by spots or spent many fruitless hours looking for the missing reef. If reef construction is conducted by state conservation departments or well organized reef committees supported by state or local funds and guidance from fishery biologists, these frustrations can be reduced significantly.

Almost every type of scrap or discarded object has been used to construct reefs. Some materials, such as old automobiles, streetcars and other vehicles, are effective for a few years but usually are reduced to debris by corrosion and wave action in approximately six years. Wooden materials collapse even sooner due to wave surge and boring organisms that actually eat the wood. Household appliances such as stoves, refrigerators, and freezers are not recommended because they are buoyant and thus difficult to sink and keep in place. Tires, rock, concrete rubble, and other durable materials have proved more appropriate to use. In addition, artificial reefs have been built of ships, barges, dry docks, culverts, toilet bowls, trees, bricks, prefabricated shelters, and artificial seaweed. Many reefs are composites of these different materials. The cost of obtaining, preparing, transporting and placing materials often determines the types that will be used. Materials that can be obtained at no cost are, obviously, high on the preference list.

Members of scout troops load scrap tires weighted with concrete onto a boat bound for a reef site off Seagirt, New Jersey. Civic groups often initiate or join in reef building projects.

Tests on auto bodies used to build a reef off Atlantic Beach, New York, showed that corrosion and wave action reduced them to debris in about six years.

A truckload of baled tires awaits loading at a staging area in Garden City, South Carolina.

Scrap tires have been one of the most popular reef materials in recent years since they normally can be obtained free. In some cases, tire dealers will even pay to dispose of them. In addition to being readily available at no cost—over 200 million tires are discarded annually—they are relatively simple to assemble into units, are easy to handle manually or with mobile equipment such as a fork lift, and are virtually indestructible. Once on the bottom, they have a large surface area-to-volume ratio and so provide more useful habitat for encrusting organisms, motile invertebrates and fish than do other materials occupying the same amount of space. Like any other material, tires must be prepared properly to assure that there is no movement on the bottom. A large tin can filled with concrete and placed inside the tire has proved simple and effective ballast for some tire units. Using donated tires, some reef units can be made and carried to the site for 50 cents each or less.

An estimated 1,500 tire reefs have been built around the world. The largest, consisting of nearly two million tires, is a mile and a half offshore near Fort Lauderdale, Florida. Since last fall up to 1,500 tires have been added to the reef every day.

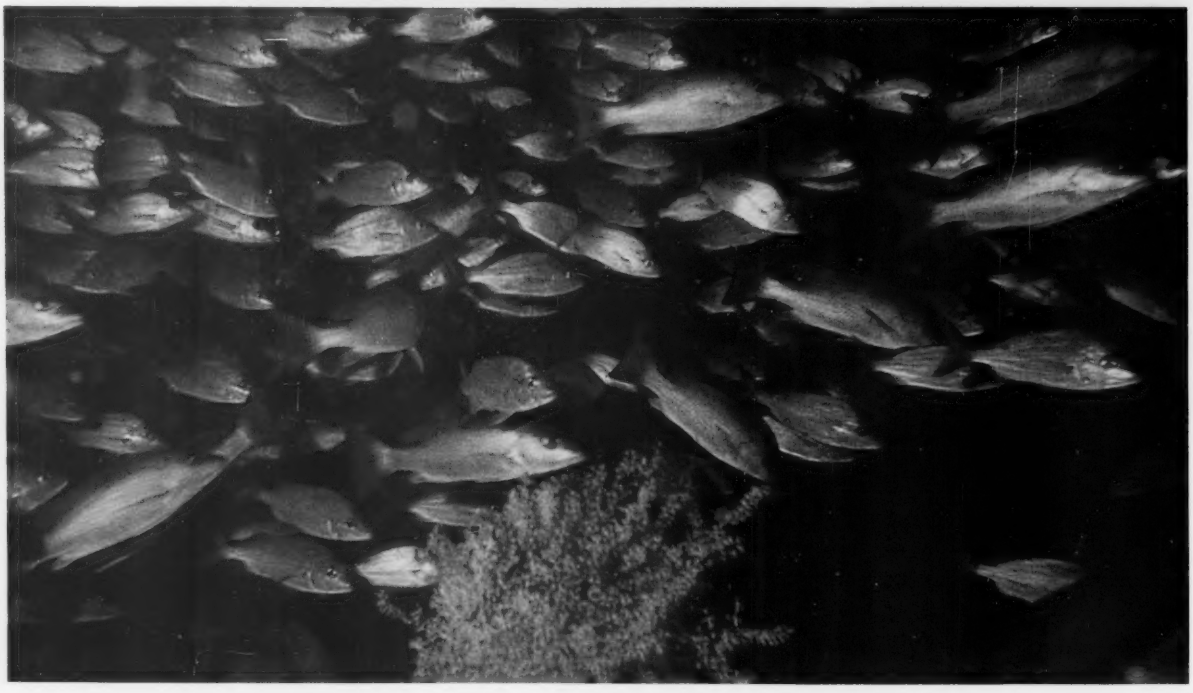
The interests of individuals and groups, other than sport fishermen, who may use the general area where an artificial reef might be placed, must be considered when selecting the exact position for a reef. The artificial reef must not pose a hazard to navigation or interfere with anchoring. Commercial fishermen must be allowed free access to traditional fishing grounds. A reef placed near a commercial fishing ground must be well marked so fishing vessels can easily avoid the reef material. A suitable site can usually be selected by consulting the various user groups of the area.

To see that reefs are properly sited, Section 10 of the River and Harbor Act of 1899, which prohibits obstructions in navigable waters without a permit from the Corps of Engineers, applies to artificial reefs. In deciding on a permit application, the Corps listens to comments from the public, other federal, state and local agencies, and other users of the site area and makes sure that the proposed reef would not interfere with navigation or conflict with commercial fishing. Artificial reefs in navigation channels or anchorages are forbidden by the Corps and the Coast Guard. The Coast Guard, which sets design standards for buoys, suggests that plans for buoying the proposed reef be included on the drawing showing the reef's location and height that must accompany the application to the Corps. This usually will expedite Coast Guard authorization.

Buoying the reef properly is an important aspect of its construction. If the reef is located more than a few miles offshore it is difficult to obtain land ranges for determining position. If at all possible, it is wise to utilize an existing Coast Guard buoy in an area where the reef will not be a hazard to navigation. If this is not possible, there are several types of fiberglass-coated styrofoam buoys which have proved successful. Preventative maintenance of these buoys is necessary. The anchor line on the buoy should be inspected at least once every six months. If the buoy is located in an area where there is traffic from larger vessels, then a radar reflector should be installed. Radar reflectors are inexpensive and easy to build, and they give the small styrofoam buoy as strong a signal on the radar scope as the larger navigation buoys.

The National Marine Fisheries Service's artificial reef research program, completed in 1974, confirmed that habitat enhancement with artificial reefs can increase total numbers of reef fish. This study refuted the contention that artificial reefs just concentrate fish, and it demonstrated the potential for increasing stock sizes of reef fish. Quantitative information obtained from a small artifi-

Diver-biologists count number of fish species and individuals three months after installation of the artificial reef in Biscayne National Monument, Florida.



Research shows that artificial reefs increase the total number of fish rather than simply drawing fish from other areas. Here, grey snappers and grunts, avoiding strong currents, crowd inside a sunken ship in an artificial reef off Singer Island, Florida.

Figure 1. Visual Counts of Fish on Artificial and Adjacent Natural Reefs in Biscayne National Monument.

	Artificial Reef		Natural Reef	
	Species	Individuals*	Species	Individuals*
January 1972	—reef built—			
February 1972	29	143	38	368
April 1972	51	251	58	760
August 1972	56	674	46	687
February 1973	43	337	37	377
August 1973	44	992	40	1027
February 1974	35	563	39	753
April 1974	27	776	33	929
August 1974	48	921	48	948

*Except gobies

Fisherman shows off a mackerel caught over an artificial reef off Murrells Inlet, South Carolina. Artificial reefs improve recreational fishing, with consequent economic benefits for shore communities.

cial reef and an adjacent coral patch reef in Biscayne National Monument, Florida, showed that the artificial reef doubled the habitat needed to support reef fish and also doubled the number of fish in the area. The artificial reef was built in January 1972 to be roughly the same size as the natural reef. In the following months counts of numbers of species and of individual fish rose rapidly at the artificial reef. By August 1972, counts at the two reefs were similar, and thereafter they fluctuated seasonally at both reefs (see Fig. 1). The potential use of artificial reefs in fishery management now becomes obvious—artificial reefs provide more fish.

A joint National Marine Fishery Service-South Carolina Marine Resources Department study off Murrells Inlet, South Carolina, showed that 16 percent of the private boat anglers fishing out of Murrells Inlet did so because of the artificial reefs offshore. This group accounted for almost ten percent of the gross expenditures by private boat fishermen in the Murrell Inlet area.

A useful publication providing more detail on all aspects of reef construction is "How to Build Marine Artificial Reefs," by R. O. Parker, R. B. Stone, C. C. Buchannan and F. W. Steimle, Jr. It and other publications on artificial reefs are available from the Office of Marine Recreational Fisheries, NOAA/NMFS, Washington, DC 20235.

Most of the successful reefs built in the United States have been cooperative efforts. Liaison between federal and state governments, industry, and fishermen can reduce both the time required to build a large reef and the cost. Following the lead of the early South Carolina fishermen, interested individuals and organizations can play a major role in helping to develop the potential that artificial reefs have as practical fishery management tools. These reefs, if properly constructed and properly buoyed, can be used to enhance existing rough bottom habitat, develop quality fishing ground close to access areas, and benefit both anglers and the economies of shore communities. ■

The author (right) and colleague R. O. Parker toss a fish trap overboard near an artificial reef off Murrells Inlet, South Carolina. Studies involving trapping and tagging of fish found that fish occassionally migrate between reefs 50 or 100 feet apart, but rarely travel 150 or 300 feet.
Don Carl Steffen.

On July 1, 1977, the National Wildlife Federation petitioned the Department of the Army, the Department of the Interior, and the President's Council on Environmental Quality to adopt procedures for compliance with the Fish and Wildlife Coordination Act. The petition has since been endorsed (at the time we went to press) by 31 state fish and wildlife agencies. In this article the author, General Counsel to the Federation, highlights the basis of the petition and its major recommendations.

Promises, Promises: Has Mitigation Failed?

by **Oliver A. Houck**

A friend of mine in Louisiana took a Corps of Engineers District Engineer into the marsh some years ago, and they came upon a Cajun trapper cleaning pelts on a small island. My friend and the D. E. were dressed in old civies. The trapper showed them his few raccoon and nutria skins and shook his head. "The life, she's gone from the marsh," he spat. "All you find now is the big ditch. GoddamnArmyengineers." He fingered his knife and the blade gleamed in the morning sun. "I wish I had one of them Armyengineers on this li'l islan'. I'd skin 'im up real good."

They left the island, my friend and the D. E., without making any introductions. Later my friend told me the story, smiling. "What do you think would have happened if I had *told* him who the D. E. was?"

Since that time I've been all over the country, talking with people who are faced with water projects—and the story seems less humorous and more universal. In many areas of the country—in fact practically all but the arid sections of the Southwest—when you get away from the Chamber of Commerce dinners, the Water Users Association meetings and the hearings run by Congressmen who'd like another project in their district, you discover a very different feeling about water resource projects. It isn't just trappers and it isn't just hunters. It's not just fishermen, oystermen, crabbers and shrimpers. You find it in graduate schools of biology and in organizations of small farmers. You find it in historic preservation associations, zoological societies, and in thousands of bands of bird watchers. You get it from people who pump gas and from reference librarians. They have seen the resources they care about—the natural water systems, upland, riverine and coastal—ripped off by one water resource project after another. And when it came to mitigation—to real honest-to-God acquisition of habitat and its improvement to replace the millions of acres dredged and drained and inundated—they've received very little in return.

The wild turkey is a favorite of outdoor Americans and has become an important national symbol in late November at least. The Corps of Engineers' Gaithright Dam will inundate 2,500 acres of the State of Virginia's best wild turkey breeding grounds—the T.M. Gaithright Wildlife Management Area. No plan for acquiring mitigation habitat has been proposed.

They have seen reservoirs as big as Oahe in South Dakota take over 100,000 acres of river bottoms, 20 years ago, and its mitigation plan still "pending." They have looked at the big channelization machines grinding down the Cache River and Bayou DeView in Arkansas, the Obion and Forked Deer Rivers in West Tennessee, the Atchafalaya River in Louisiana, without (until they did something about it) the semblance of a plan for mitigating losses to—in these three projects alone—over a million acres of wetlands. They've seen the big dams of the Northwest on the Columbia and the Snake shock, chew up, and now reduce to the danger level those large runs of salmon and steelhead which were once the pride of the region. In return, a few fish hatcheries and almost no wildlife land.

These people have seen entire states, huge states, riddled with federal reservoirs, criss-crossed with federal canals and channels, without an acre—not one acre—purchased or improved as compensation for fish and wildlife habitat lost. Texas. Louisiana. South Carolina. . . . They are seeing the federal mitigation system massively fail.

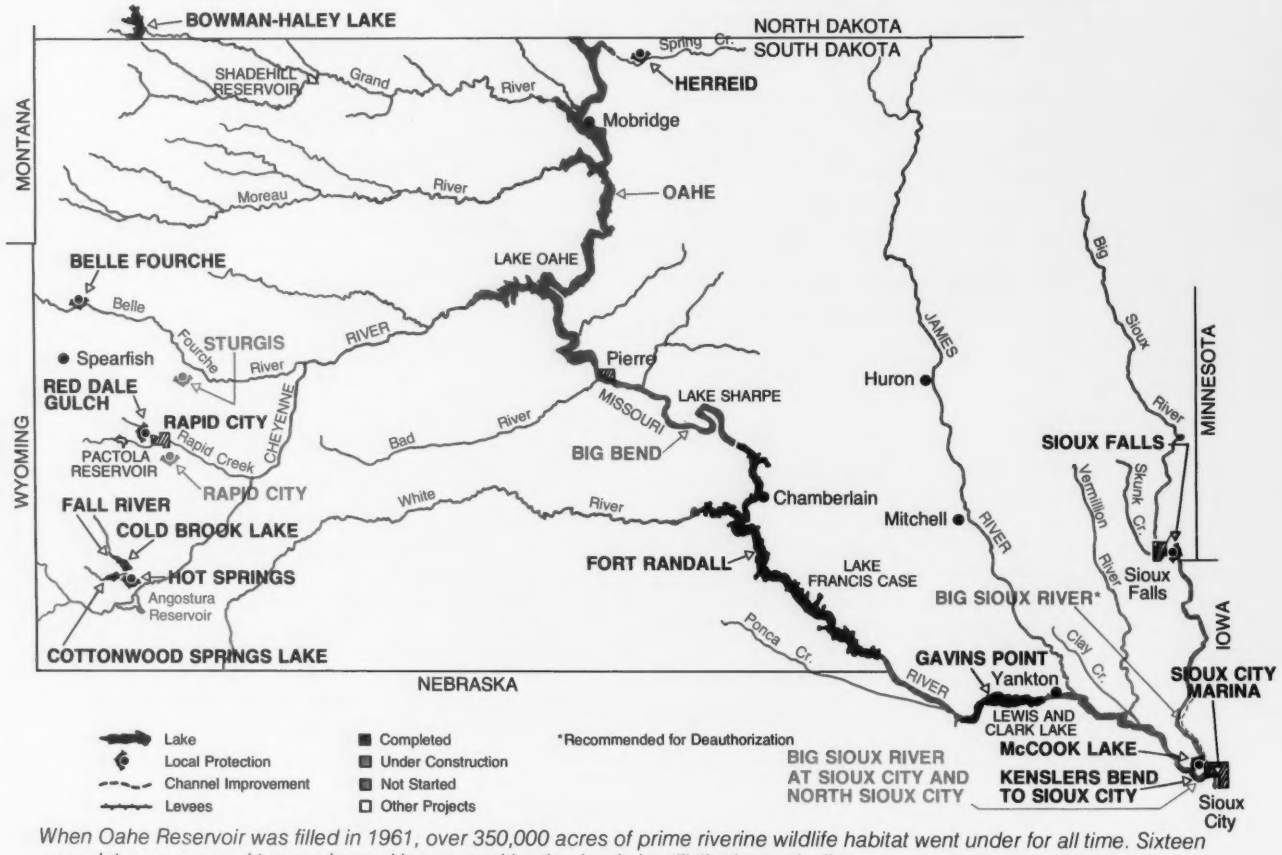
The construction agencies are at a crossroads. They can meet a rising tide of skepticism as they have in the past with stepped-up public relations. Or they can for the first time try on a systematic basis to compensate for the impacts of their projects on habitat, in what they've done, and are doing, and will do. Water resource planning and building has been going on for a long time. It has become pretty evident where the loopholes are, where the slippages have been occurring for fish and wildlife. We may not be able to come up with the perfect system, but it is time to put a few specific suggestions for improvement on the table.

At the heart of the Fish and Wildlife Coordination Act is the development of a mitigation plan through the

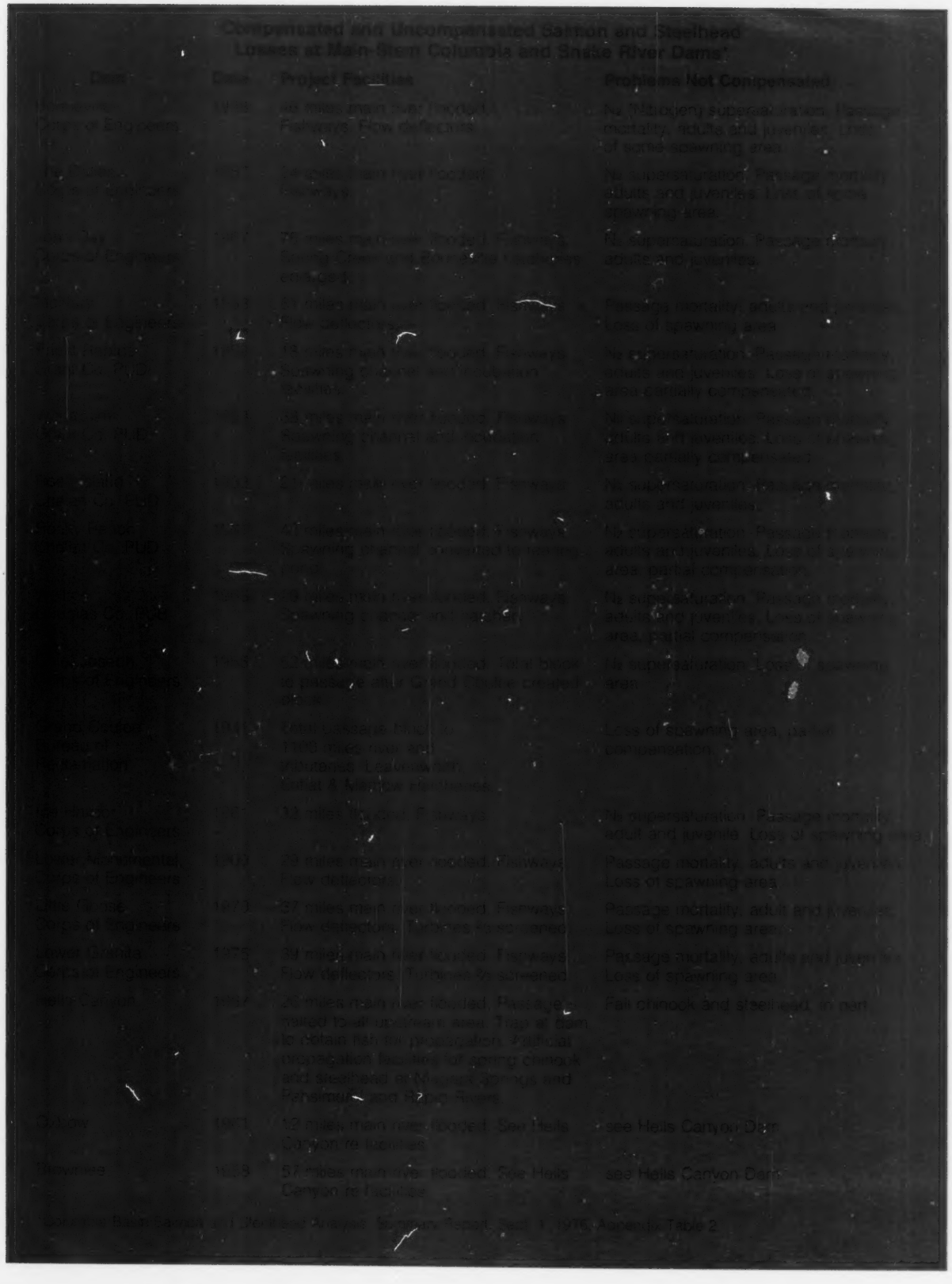
(intended) specific recommendations of the Secretary of the Interior and the determination by the construction agencies of those measures (including the acquisition of replacement habitat) which should be included in the project plan to offset project losses. Those features which are recommended and adopted have become in common parlance the "mitigation."

The threshold problem is that for over a decade there has been no uniform system for how mitigation recommendations and decisions are arrived at. Until recently, construction agencies have felt free to choose the method which produces the lowest results for fish and wildlife (and, correspondingly, at the least project cost)—the "man-day use" method. In summary, this method consists of figuring out how many hunters or fishermen currently use an area to be destroyed, giving them a dollar value (how does $3 for a day in the outdoor sound?), and then figuring out how much (or how little) can be bought in mitigation.

The shortcomings of the "man-day use" method have long been obvious. Basically you cannot replace fish and wildlife losses by moving sportsmen around. Once inundated by dams or drained by ditches, these resources are gone. The "man-day" method, by focusing on *users* rather than on *resources,* twisted the purpose of the Coordination Act. It also focused almost exclusively on *consumptive* use of the area—to the exclusion of more



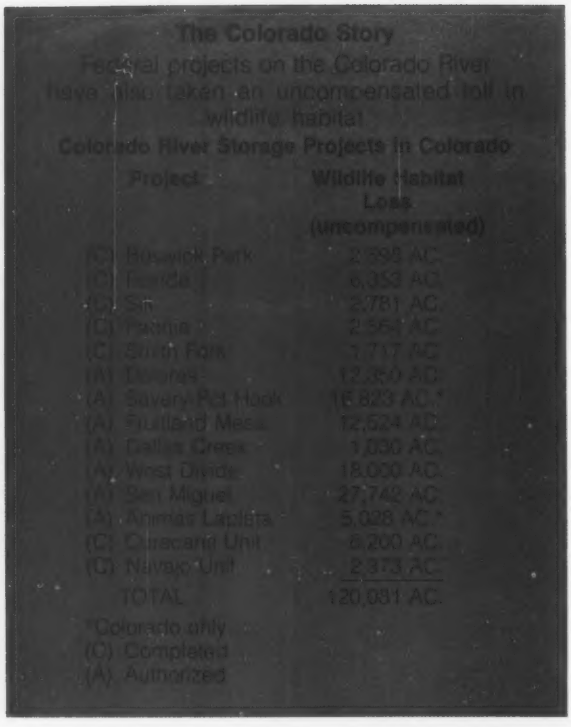
When Oahe Reservoir was filled in 1961, over 350,000 acres of prime riverine wildlife habitat went under for all time. Sixteen years later, a proposal to acquire and improve mitigation lands is still "in the works."



Compensated and Uncompensated Salmon and Steelhead Losses at Main-Stem Columbia and Snake River Dams[1]

Dam	Date	Project Facilities	Problems Not Compensated
Bonneville	1938	48 miles main river flooded. Fishways. Flow deflectors.	No fishways; superaturation. Passage mortality, adults and juveniles. Loss of some spawning area.
	1957	Fishways improved. Flow deflectors.	No superaturation. Passage mortality, adults and juveniles. Loss of some spawning area.
	1971	75 miles main river flooded. Fishways. Spillway deflectors. Powerhouse screens.	No superaturation. Passage mortality, adults and juveniles.
The Dalles	1957	24 miles main river flooded. Fishways. Flow deflectors.	Passage mortality, adults and juveniles. Loss of spawning area.
	1971	76 miles main river flooded. Fishways. Spillway deflectors. Powerhouse screens.	No superaturation. Passage mortality, adults and juveniles. Loss of spawning area partially compensated.
John Day	1968	76 miles main river flooded. Fishways. Flow deflectors.	No superaturation. Passage mortality, adults and juveniles. Loss of spawning area partially compensated.
	1971	76 miles main river flooded. Fishways. Spillway deflectors. Powerhouse screens.	No superaturation. Passage mortality, adults and juveniles. Loss of spawning area partially compensated.
	1975	76 miles main river flooded. Fishways. Spillway deflectors. Powerhouse screens.	No superaturation. Passage mortality, adults and juveniles.
McNary	1953	61 miles main river flooded. Fishways. Flow deflectors.	No superaturation. Passage mortality, adults and juveniles. Loss of spawning area partial compensation.
	1957	Fishways improved. Flow deflectors.	No superaturation. Passage mortality, adults and juveniles. Loss of spawning area partial compensation.
	1971	92 miles main river flooded. Fishways. Flow deflectors. Powerhouse screens.	No superaturation. Passage mortality, adults and juveniles. Loss of spawning area partial compensation.
	1975	92 miles main river flooded. Fishways. Flow deflectors. Powerhouse screens.	No superaturation. Loss of spawning area.
Ice Harbor	1961	32 miles main river flooded. Fishways. Flow deflectors.	Loss of spawning area, partial compensation.
	1975	32 miles main river flooded. Fishways. Flow deflectors. Powerhouse screens.	
Lower Monumental	1969	28 miles main river flooded. Fishways. Flow deflectors.	No superaturation. Passage mortality, adult and juvenile. Loss of spawning area.
	1975	28 miles main river flooded. Fishways. Flow deflectors. Powerhouse screens.	Passage mortality, adults and juveniles. Loss of spawning area.
Little Goose	1970	37 miles main river flooded. Fishways. Flow deflectors. Powerhouse screens.	Passage mortality, adults and juveniles. Loss of spawning area.
	1975	37 miles main river flooded. Fishways. Flow deflectors. Powerhouse screens.	Passage mortality, adults and juveniles. Loss of spawning area.
Dworshak	1973	54 miles main river flooded. Fishways. Flow deflectors. Powerhouse screens.	Passage mortality, adults and juveniles. Loss of spawning area.
	1974	54 miles main river flooded. Fishways. Flow deflectors. Powerhouse screens.	Fall chinook and steelhead, in part.
Brownlee	1958	58 miles main river flooded. Passage through Oxbow and Hells Canyon. Loss of fish to reservoir fisheries. Fishways for propagation. Artificial propagation facilities for spring chinook and steelhead in Weiser, Payette and Pahsimeroi rivers, Idaho.	
Oxbow	1958	13 miles main river flooded. See Hells Canyon Dam.	see Hells Canyon Dam
Hells Canyon	1958	51 miles main river flooded. See Hells Canyon Dam.	see Hells Canyon Dam

Source: Snake River Salmon and Steelhead Analysis Summary Report, April 17, 1975, Appendix Table 2.


The Colorado Story
Federal projects on the Colorado River have also taken an uncompensated toll in wildlife habitat.
Colorado River Storage Projects in Colorado
Project
Wildlife Habitat Loss (uncompensated)
(C) Roswick Park 2,595 AC
(C) Fruitla 6,353 AC
(C) Sil 2,781 AC
(C) Paonia 2,564 AC
(C) Smith Fork 1,717 AC
(A) Dolores 12,250 AC
(A) Savery Pot Hook 16,823 AC *
(A) Fruitland Mesa 12,524 AC
(A) Dallas Creek 1,030 AC
(A) West Divide 18,000 AC
(A) San Miguel 27,742 AC
(A) Animas La Plata 5,028 AC *
(C) Closcana Unit 6,200 AC
(C) Navajo Unit 2,373 AC
TOTAL 120,031 AC
*Colorado only
(C) Completed
(A) Authorized

passive uses such as photography and bird watching. Those values never got plugged into the equation. Nor did it acknowledge *future* use of the area (although project benefits are sometimes computed for as much as one hundred years away). Nor did it recognize the interrelationship of habitats, the importance of one area (a staging area for migratory waterfowl, for example) to the recreational use and enjoyment of another area hundreds of miles away.

Nothing in law required the use of the outdated and inadequate "man-day use" planning method. Historically, construction agencies relied on "Senate Document 97," asserting that it in some way tied their hands to "man-day use." Senate Document 97 did no such thing, but that argument is now moot—the Water Resources Development Act of 1974, in approving the Principles and Standards for water resource planning, repealed Senate Document 97. Nonetheless, the Corps of Engineers for one has continued to follow a policy described in 1972 public works authorizations hearings as follows:

> *"until such time as an acceptable procedure of methodology for evaluating intangible habitat values has been approved, the Corps mitigation plans will be governed by the acquisition and development of only those lands needed to support the user days lost when mitigating project induced fish and wildlife losses."*

Well, an "acceptable procedure" has arrived. In coordination with the Corps and other agencies, the U.S. Fish and Wildlife Service has developed a far more valid methodology for evaluating fish and wildlife losses and for recommending appropriate mitigation. Called "Habitat Evaluation Procedures" (HEP), the method focuses rightly on habitat as the determining factor. Oversimplification does HEP little justice, but in principle: from calculating the extent and type of habitat affected by the project the Service is able to project the extent and nature of habitat needed to be acquired and improved to mitigate the losses.

The HEP system is biologically sound, but its reception by construction agencies has been cool. Without explanation we are seeing HEP evaluations rejected by construction agencies which insist on using the "man-day" method—in Oklahoma, Kansas, North Dakota, Louisiana. The public continues to see weak and inconsistent recommendations. More wildlife habitat goes down the tube. The remedy is not difficult: adopt the HEP procedures as a uniform system for evaluating fish and wildlife losses and recommending appropriate means and measures for mitigation.

The second failure of standards comes when the construction agency determines just what means and measures are "justifiable" for mitigation. There are no standards for this decision either, and we have seen rejections of Fish and Wildlife Service proposals with no basis beyond "unjustifiable" by way of explanation to the Service or to the general public. We have seen other rejections based on statements that the "benefits of the mitigation recommendations do not exceed the costs," despite the fact that Congress clearly intended in the Coordination Act that benefit/cost analysis *not* be used for mitigation plans. Here again we see an array of inconsistency, decisions on mitigation without reasons, and reasons which, once surfaced, are unlawful. The corrective step is again not difficult: a statement of factors on which the construction agencies' "justifiable" decision is based, and written application of these factors into each mitigation decision. Comparative costs of alternative, HEP-based mitigation plans are a legitimate factor; benefit/cost analysis of each plan is not.

The best mitigation planning in the world will produce nothing unless it is funded and executed. Neither happens very well.

The first funding problem arises in the planning stages. Under the Coordination Act, the Fish and Wildlife Service is supposed to get project funds to conduct the needed mitigation studies. For whatever reason, those funds are not always provided. Examination of dozens of projects over a period of years has led to the same complaint by Fish and Wildlife Service agency personnel—"They didn't give us enough money to do the studies."—and by Corps and BurRec personnel—"They didn't ask for it." And so it goes, Alphonse and Gaston stand back and point their fingers at each other and fish and wildlife take another beating.

A second problem, even if the money is forthcoming, appears to be "lack of personnel" to conduct the necessary HEP studies. Since Fish and Wildlife Service personnel ceilings are fixed, "What can we do?" What they do do is throw up their hands, and watch fish and wildlife habitat disappear. This doesn't have to happen either. If sufficient Fish and Wildlife Service personnel are not available, the Service can develop regulations and procedures for delegating parts of the tasks, under close Service supervision, to other expert (state) agencies, qualified

In the South, the Numbers Tell the Mitigation Story*

	Direct Habitat Losses from Corps Water Projects	Mitigation Acreage Requested by USFWS	Mitigation Acreage Proposed and Authorized	Mitigation Acreage Purchased to Date
Arkansas (7 projects)	711,423	561,810	83,500	6,000 (approx.)
Louisiana (7 projects)	243,122	125,468	12,800	12,800
Mississippi (9 projects)	281,500	189,800	15,000	15,000
Total	1,236,045	877,078	111,300	33,800

*Based on USFWS data

university programs, and consultants. The Service has been quite unwilling to acknowledge its responsibility to make these assessments and recommendations on all projects. On the other hand, it has been quite upset at the thought of someone else doing them. The Service can't have it both ways. It should accept its full responsibility to make these studies and recommendations, welcome it in fact, and devise a system to get the job done.

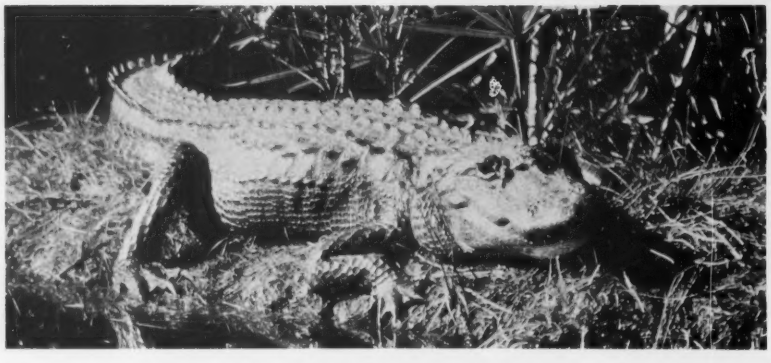
The next slip in execution comes at authorization and appropriations time. In the past, construction agencies have been only too willing to propose that we "get on with the project now," and do something about mitigation later. Too often when "later" rolls around, the lands available for mitigation have been drained, ditched, burned over, cleared, second-homed, and developed. Any option for replacing the habitat base is gone. To be sure, the agencies cannot be responsible for what Congress funds, but they are certainly responsible for what they themselves ask for. For openers, they can propose mitigation each and every time they are proposing authorization and appropriations.

The final misstep in execution comes when the mitigation plan is finally funded and taken to the field. The same hearts and minds are not available to execute the plan; cold feet set in, hearts flutter, and there is soon a rush for the rear. Those same agency leaders who were so determined to condemn land and "relocate" these unfortunates who were living "below the project boundary," those same leaders are now inexplicably unwilling to condemn land for the mitigation plan. Alternatives, almost any alternatives, are offered to take the heat off—pay off the state in cash, look for willing sellers only, buy partial easements, anything. That mentality has got to go. Under the Coordination Act it is all one project, and what's sauce for construction is sauce for mitigation.

The two approaches suggested above will go a long way in future projects to make fish and wildlife interests a genuine part of water projects. But they will not cure today's problem, or tomorrow's. There are several hundred projects on the drawing boards right now, many devoid of mitigation planning, others with only token plans ("please fill the reservoir when the trees are not in bloom"). These projects are what we have seen for the past ten years and will see for the next ten. From the Corps—Russell Dam in Georgia, Parker Dam in Oklahoma, Cedar Point in

One of the most difficult aspects of mitigation is in-kind replacement of high-quality fisheries habitat. Trade-offs of running streams for flat-water lakes, trout for carp, are increasingly unacceptable to fishermen, biologists and others concerned about continuing diversity of species.

(U.S. Fish & Wildlife Service photos)



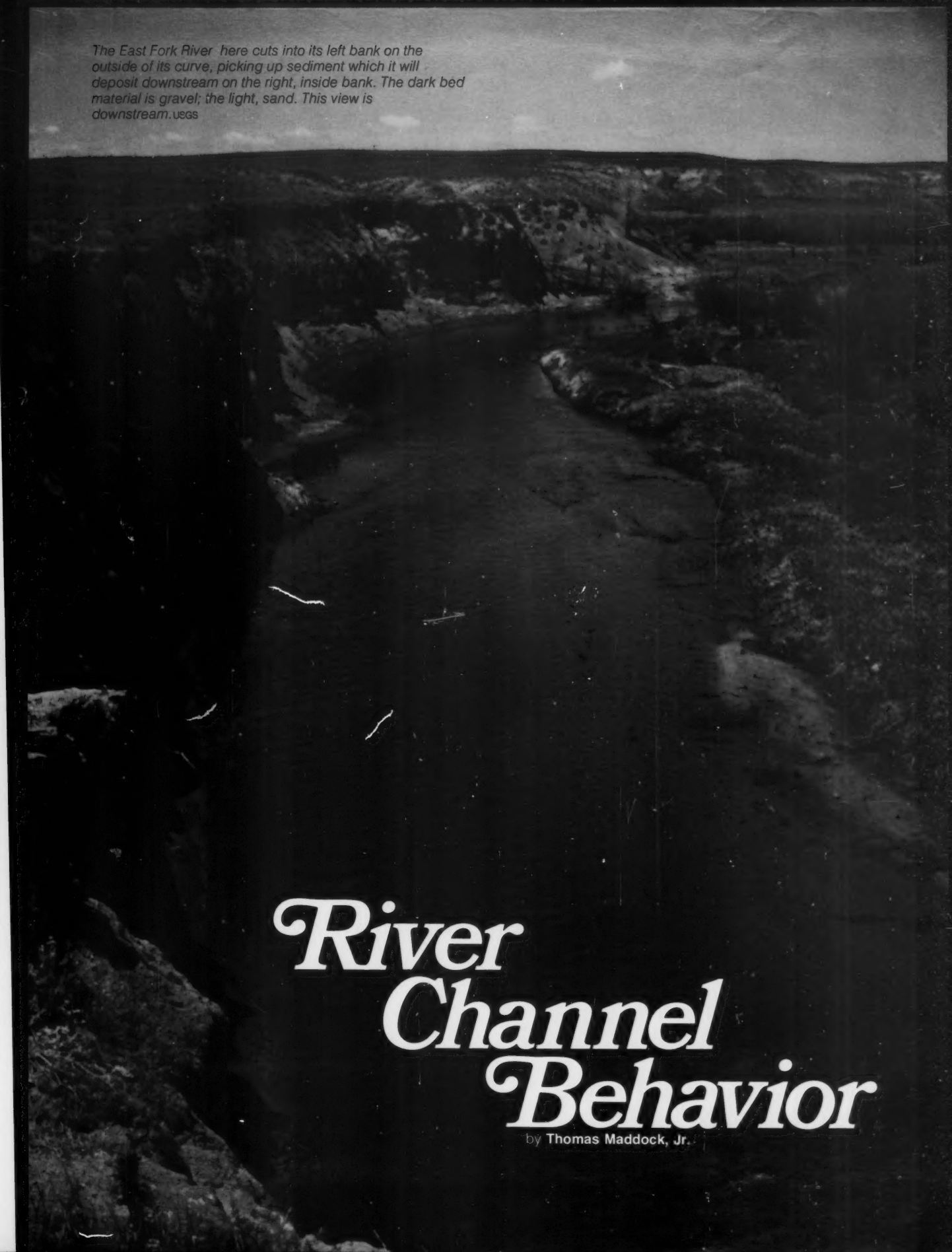
The following is from a notice in the Federal Register on an environmental impact statement: *"Bowie Dam and Lake, Pascagoula River Basin, Miss. and Ala. The statement is a legislative action involving proposed construction of a multi-purpose reservoir, for flood control, water supply, recreation, and fish and wildlife enhancement. An unspecified number of residences will be displaced. Approximately 5,500 acres will be inundated by the project; rare or endangered species for which this may serve as habitat include the bald eagle, the peregrine falcon, the ivory-billed woodpecker, Bachman's Warbler, and the American alligator."* No plan for acquiring mitigation habitat has been proposed.

Kansas, Bayous Chene, Boeuf and Black in Louisiana . . . the list goes on . . . all of them without a mitigation plan. From the Bureau of Reclamation—the Central Arizonas and the Central Utahs and the Navajo project in New Mexico, with little more mitigation planning. It is not enough to tell people who are interested in fish and wildlife that—come 1990—things will be different. We have lost too much already and we are continuing to lose it every day.

As I stated at the beginning, we are looking at entire states where not a single acre has been acquired and developed as replacement habitat. What is needed is a crash, cooperative program to bring existing projects into compliance. The construction and wildlife agencies should start by identifying those major on-going projects with inadequate existing mitigation planning. A schedule should be developed for the preparation of HEP evaluations, recommendations, and proposals for authorization and implementation. A second cut should be made for new construction starts, and a third for the remainder of authorized projects not yet slated for construction. Aggressively approached, the backlog could be cleaned up in three to five years. It will take additional funding and manpower, although with some imaginative administration the manpower demands can be kept within bounds. Most importantly, it will take the commitment to get the job done thoroughly and systematically, starting right now.

This kind of a commitment—to restore and repair the habitat base for fish and wildlife—will go farther to win conservationists and environmentalists of all stripes to water resource development than all the fine slogans and the brochures that money can buy. ■

Editor's Note: This article is being published in keeping with Water Spectrum's policy of providing an open forum on water resources topics. Mr. Houck's article represents the views of a leading conservationist on the important topic of mitigation and his recommendations on needed policy reforms. The Office, Chief of Engineers, is presently considering the National Wildlife Federation's petition as well as the views of Federal and the state Fish and Wildlife agencies in developing the Chief of Engineers mitigation policy.



The East Fork River here cuts into its left bank on the outside of its curve, picking up sediment which it will deposit downstream on the right, inside bank. The dark bed material is gravel; the light, sand. This view is downstream. USGS

River Channel Behavior

by **Thomas Maddock, Jr.**

Shrubs grow on the modern flood plain of the East Fork River, Wyoming. In more humid areas, undeveloped flood plains are covered with trees. USGS

Man has lived beside streams flowing in their own alluvia since time immemorial, and his efforts to control the constant variations in stream channels are equally ancient. Yet even today these attempts by man, to a considerable extent, are a no-win game.

The behavior of rivers flowing in alluvia is dependent upon the discharges of both water and sediment. Our problems usually arise from a failure to consider the discharge of sediment as being equally as important as the discharge of water.

The instability of a river channel is the result of the variation in the boundary of the channel, particularly the bed. As soon as the sediment begins to move, a proportion of it is redeposited on the bed downstream. With increasing discharge of water and sediment, these deposits take on various recognizable forms such as ripples, dunes, bars, and pool and riffle configurations. Each of these bed forms is associated with a particular combination of water and sediment.

From a hydraulic standpoint, the most important characteristic of an alluvial channel is that these bed forms control and determine the amount of hydraulic roughness—or degree of difficulty water encounters during its movement through a specific reach of channel. Rigid boundary hydraulics do not apply to alluvial channels once an appreciable amount of sediment is set in motion and the bed becomes deformed. The scope of hydraulic roughness associated with bed forms is limited, ranging from a flat bed with no deformation and low roughness, to a bed covered with dunes with a large height to average water depth ratio and a high hydraulic roughness. Because of the relation between sediment transport and bed form, hydraulic roughness is associated with sediment transport.

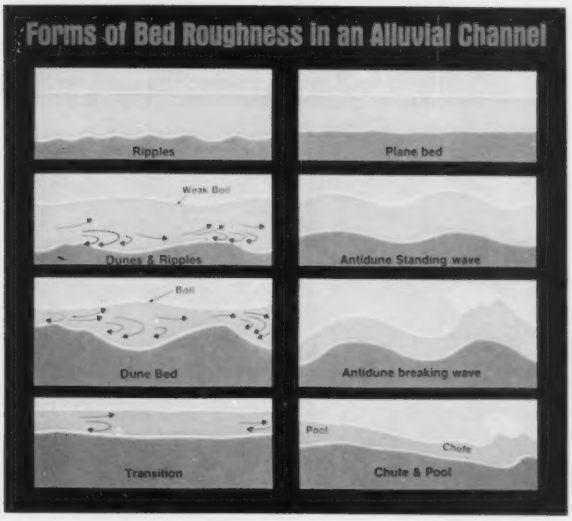
The effects of movement of water and sediment in natural river basins under specific climatic, geologic and topographic conditions are masked by the stream's development of a fairly stable relationship between discharge of water, discharge and particle size of sediment, and the vegetative

Thomas Maddock, Jr., is a retired senior scientist, formerly with the U.S. Geological Survey.

conditions of the river banks. This relationship is called a "regime," a term that derives from a system of canal design and is reflected in the stream's "geometry"—the relation of width, depth and velocity to discharge. These natural relationships fail during unusual conditions of water and sediment discharge, usually during flood periods, but potentially during any period of discharge as long as appreciable amounts of sediment are moved.

Thus any condition that sharply increases or decreases the supply of water and/or sediment (together with changes in the sediment particle size), over or under what might be considered a normal supply, will result in channel instability.

Given this simplistic statement of a complex problem, it is clear that the development of bed forms plays a key role in the stream regime. The state of the art is such, however, that we have no adequate theory about bed form formation. The only thing we can say with certainty is that with all the possible combinations of changes that can take place in the bed, those which lead to equilibrium persist.

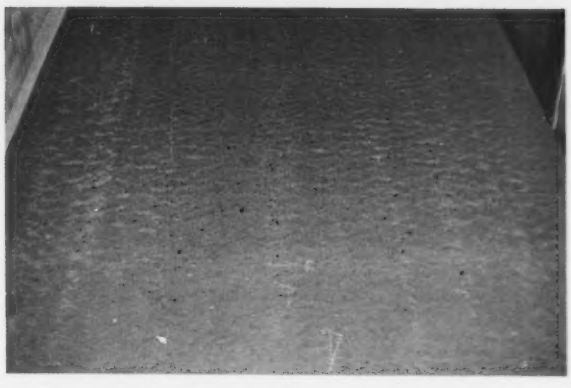


Water surface characteristics are related to channel bed forms. USGS

Those which do not lead to equilibrium are destroyed. Consequently, equilibrium is statistical and applies to an average condition in space and time. Under these conditions of average discharge of water and/or sediment an alluvial channel remains reasonably in equilibrium. There are no chain reactions.

Now let's look at the nature of the alluvial channel. The drainage basin provides the discharges of water and sediment (when speaking of sediment in general, characteristic particle size must be considered as well as the amount and shape). Over a period of time, at any one point the stream adapts its slope, width, depth and velocity to these discharges of water and sediment. Under a steady state condition, there is one slope, one velocity, one depth, one width. This is the self-formed, unconstrained or regime condition. The channel is reasonably stable, and is a benchmark by which all others are measured. In a steady state, the way which the discharge of

Using an artificial flume, Colorado State University and the U.S. Geological Survey have gathered information on channel bed forms under various conditions. With the bed slope close to horizontal and flow tranquil, the surface of the sand bed is smooth, a condition known as a plane bed. USGS



As slope increases, ripples begin to form in the sand bed of the artificial flume. USGS

water and sediment breaks down into velocity, width, depth and slope is controlled by maximization and minimization processes that have yet to be scientifically established.

In the formation of natural channels, from a day-to-day point of view, slope tends to have the least variation, with width being the next most consistent. At any point on a stream system, the natural variation in discharge of water and sediment is handled by corresponding changes in velocity and depth. If the overall stream geometry is consistent, that is, if the changes in width, depth and velocity are consistent with changes in discharge, then the relation between the discharge of water and sediment tends to be consistent. Consequently, it is to be expected that different drainage basins have different geometries.

The foregoing discussion tends to emphasize the similarities and consistencies of river behavior. Most of the difficult problems of river management, however, come from the behavioral inconsistencies—the effects of floods, of variability in the relationship between discharges of water and sediment, and of natural changes in slope. To these must be added the changes caused by the works of man—streamflow regulation, levees, trapping of sediment, alteration of channel slope, channel construction, etc.

These inconsistencies are best observed at specific sites and specific reaches on alluvial channels. Under such conditions, particularly for reaches with a length of 10 to 12 times the width, average slope may be considered to be a constant. The stream channel will then represent the self-formed condition for a particular discharge of water and sediment, with a particular type of bed form. Any departure from these discharges will result in a different bed form and the change in bed form will change the velocity-depth ratio.

If the unit discharge (the discharge per unit of width) together with the stream slope and the characteristic particle size of the transported sediment remain constant, a reduction in the amount of transported sediment will result in a change in bed form. This further causes an increase in roughness, a reduction in mean velocity, and an increase in average depth. Conversely, an increase in the amount of transported sediment under like conditions yields a reduction in roughness with an increase in mean velocity and a reduction in the mean depth.

Because the size of the transported sediment is not uniform and because the coarser fraction of the bed material may move into or out of the transported load through sorting, the sediment concentration will change. Reactions to a reduction of the sentiment entering a stream reach include an increase in roughness, an increase in median size of the transported material, and a small increase in the amount of sediment being transported through the reach.

How all these variables relate to and balance each other depends upon the condition of the bed at the time the change in sediment transport occurs.

If the bed is already in a rough condition, little change may take place in that phase of the adjustment. The bulk of the change will be taken up by an increase in the size of the transported material and an increase in the amount of sediment removed from the reach. This results in an increased depth or width of the stream channel with a reduction in velocity. Whether the change in depth appears as scour or an increase in gage height for a given discharge depends upon the constraint on the change in channel slope.

If the amount of sediment moving into the reach is increased and the reach resistance is already low, the coarser material being transported is dropped on the bed and there is a reduction in transported sediment.

The river flood plain is an example of adjustments to changes in the discharge of water and sediment. Streams moving rapidly increasing concentrations of sediment with increasing discharge do not have flood plains. Such streams are usually found in regions of relatively low runoff and large amounts of available sediment. In more humid areas there is a large amount of water to move the normally available sediment. Consequently, in the humid areas the sediment concentrations do not increase with discharge as much as those of the arid regions. In a channel with a flood plain the overbank flow tends to have the lowest concentrations and moves at the slowest velocities. The sediment being moved tends to remain in the main channel. Thus the sediment concentrations

are increased in areas of high velocity and decreased in areas of low velocity.

Should the quantity of sediment delivered to the reach increase during overbank flow, the amount escaping from the channel would increase. However, this material would be deposited a short distance from the channel in the form of natural levees. This increases the unit discharge in the main channel leading to a balance with the increase in discharge of sediment.

If the amount of sediment delivered to the reach during an overbank stage declines, the stream must decrease its mean velocity. The end result of the adjustments is that the stream widens. The process destroys the existing natural levees, allows greater overbank flow, reduces the unit discharge in the channel, and, in turn brings the stream back into a "regime" condition.

In making these adjustments, the stream follows the same simple rule—that which does not tend to promote equilibrium is destroyed and that which leads to equilibrium is preserved. In the process the stream may make temporary or some permanent adjustments in the width, discharge of sediment, size of sediment, resistance to flow, and slope, all leading to changes in the depth and velocity for a particular discharge of water. Because there is a limit to the amount of adjustment that can be made, the reaction to a change in an existing condition will be dependent on the initial condition itself. For example, a stream showing signs of aggradation is unlikely to react successfully to an increase in sediment transport.

In the foregoing discussion, the slope of a reach has been assumed to be essentially constant with changes in discharge of water and sediment. While this may be true, one of the uncertainties of stream behavior is change of slope within a reach or, in highly sinuous reaches, marked changes in slope

Under the right conditions, a river will choose its own path despite human attempts to confine it. This is the Walla Walla River near Milton-Freewater, Oregon, after a flood in January 1965.

The depth of flow limits the height of dunes. These, in the East Fork River, Wyoming, are about six inches tall. USGS

caused by natural conditions. Furthermore, modification of channels by man frequently results in changes in the stream slope.

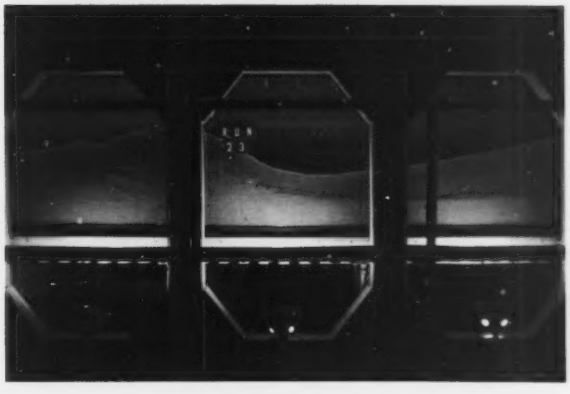
The basic reaction to an increase in slope is that the velocity must decline and/or the size and quantity of sediment being transported must increase. The decline in velocity must be accomplished by increased resistance to flow, by an increase in depth, or by an increase in width. This statement is at odds with the usual assumption that velocity must increase with an increase in slope and that scour is the result of the increased velocity.

However, an increase in velocity means a reduction in the channel area. Scour could not take place without the formation of a nickpoint or some localized reach of increased slope. Such conditions are observed, but more frequently they are not. More generally, the rule is that scour is accompanied by low velocities and fill by high velocities. This is inevitably true if stage-discharge relations are stable.

Like the effect of change in sediment transport, the effect of change in slope depends upon the condition at the time of change. What usually happens is that with an increase in slope, the bed forms change in the direction of increased resistance to flow. At the same time, these bed forms lead to increased depth and width because of increased stress on the bed. Furthermore, sorting becomes active—resulting in an increase in size and amount of sediment transport. Note that all these changes are in the direction of maintaining the same velocity with an increase in slope, while the enlargement of the section is toward maintaining the same transport on a steeper slope and a lower velocity. The degree to which the changes take place depends upon local conditions and may vary within a reach of the river.

Modification of stream width is another frequently observed activity of man. Change in width alters the discharge per foot of width at any particular location; hence, it is the equivalent of increasing or decreasing discharge with sediment concentration constant. The reaction to a decrease in width is initially an increase in resistance to flow with the end product being a flatter slope, an increase in the amount and

Further increasing the slope of the artificial flume produces dunes on the sand bed. USGS



With rapid flow, scouring behind sand waves and filling in front of them makes the waves seem to move upstream. These bed forms are called antidunes. USGS

The water surface over antidunes resembles the bed form beneath it. As they move upstream, antidunes and the waves above them grow in size and eventually break. This view is downstream. USGS

size of transported sediment and/or an increase in the area of the stream section.

Levees are a method of increasing the discharge per unit of width, usually with the result of decreasing the sediment concentration. The reaction of increased resistance to flow causes an increased stress on the channel banks. Consequently, construction of levees usually leads to the construction of bank revetments, an increase in the size of the material on the bed, and a change in the stage-discharge relation for high and low discharges.

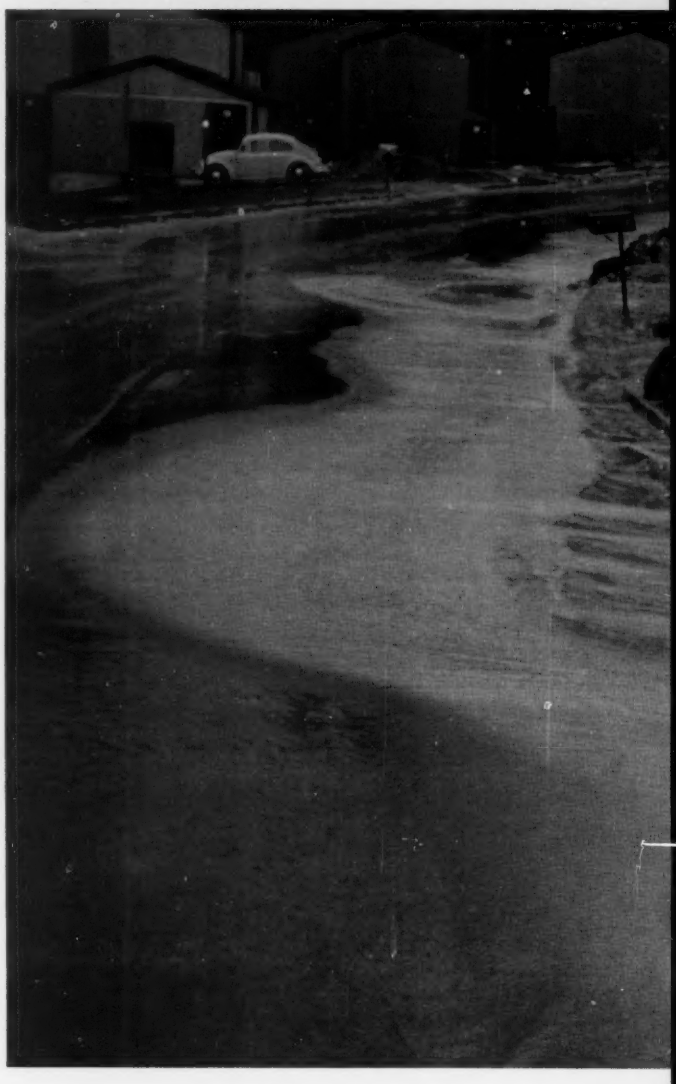
Reduction in width by bridge or culvert openings is a complex situation. Frequently the constriction requires an increase in the water surface upstream from the bridge. This results in a flatter slope upstream, a steeper slope through the opening, and usually a flatter slope downstream. The flat slope upstream requires a higher velocity to move the sediment; consequently, the resistance to flow must decline and stream depth decrease. The result is aggradation upstream from the structure and reduction in sediment transport below the area of deposition. The increase in the slope through the opening plus the reduction in sediment transport requires an increase in resistance to flow, an increase in depth and in size of the bed material. This causes scour and an enlargement of the section through the opening and for short distances downstream. Downstream from the structure, the reduction in sediment transport by filling upstream results in an enlargement of the channel section. Furthermore, in the area of high resistance near the structure the scale of turbulence extends downstream and helps enlarge the section downstream from the structure.

Once again, whether these changes are detrimental depends on the initial condition. A channel that has a tendency to aggrade will be improved by a reduction in stream width, but the effect will have to be tested under different discharges. There is no such thing as a stable channel for all ranges of discharge of water and sediment.

Increase in width usually results in a reduction of sediment transport unless the resistance to flow can decrease. This means that the section would be at the upper limit of its ability to transport sediment. In general, channel widening results in a decrease in the ability of a stream to transport sediment. Consequently, bank erosion cannot be a long-term source of sediment. That which is eroded in the normal processes of channel change is redeposited a short distance downstream so that the net channel section tends to remain much the same under a specific set of discharges of water and sediment.

While it may be possible to predict with some degree of confidence what may happen under specific changes in stream regimen, we cannot forecast when or how quickly any adjustments will take place. The reasons are that: one, we cannot forecast the time of the higher discharges that have the largest effects on stream behavior; two, and more importantly, we have to consider the effect of vegetation; and three, the resistance of the bed and banks to the attack of the moving water is not constant but is highly variable.

The influence of vegetation on stream channels is considerable, being more important for small streams than for large. Vegetation protects the banks against the attack of the stream and it provides resistance to flow which holds down velocity without the development of bed forms that lead to instability. Vegetation being a living organism is constantly encroaching



The role of sediment in river channel behavior should not be overlooked. A small stream has left its floodplain coated with sediment from erosion of a construction area upstream. USGS

on the stream during periods of low flow. It intrudes on the overly wide sections left by receding floods. Without vegetation streams would not be able to reclaim areas of erosion or to stabilize areas of deposition.

Newly constructed channels that are subject to floods are vulnerable until adequately covered with vegetation. Consequently, there is always some risk in constructing new channels to the dimensions expected under long-term conditions. It is probably better to construct a new channel to be safe under barren conditions and use the knowledge of a probable vegetative cover as a factor of safety.

This article has emphasized two points. First, that the characteristics of a stream channel are dependent on the discharge of water and on the discharge and size of the transported sediment. Second, that there are a number of ways a stream channel can respond to the changes in the quantities of water and sediment. Just what is done depends on the constraints on the system and these depend on the conditions existing at the time the change was made.

Because of the natural variability of the discharges of water and sediment, no channel is stable under all conditions. By stable is meant that the bed and banks do not change. Channels are always in equilibrium in the sense that there are no chain reactions. However, because the channel boundaries are made of movable particles, with time sediment particles may switch back and forth between bed and banks. Thus duration of a particular flow condition influences the aspects of a particular channel.

Two conclusions are presented. One, sediment transport cannot be ignored in any evaluation of stream behavior and the sediment under consideration is the total load and not just what happens to be exposed in the bed. Sediment transport is not a pollutant. It is an indispensable element in any study of alluvial channels. Two, it is clear that evaluation of river behavior is a very tricky thing, more an art than a science. Successful practitioners are invariably those who are familiar with the everyday behavior of a particular river. The fact that we have many successful projects, as well as some failures, is usually the result of long association with a particular piece of a river system. ■

Events, Deeds & Deliberations

Cooperation Saves the Day

What happens when three contiguous states are simultaneously shut down by the storm of the century? In the aftermath of the 2-day blizzard that howled across Connecticut, Rhode Island and Massachusetts on Feb. 6-7, some answers to that question emerged. They can be summarized in a single word—cooperation—governmental as well as individual.

Under the overall direction of the Federal Disaster Assistance Administration (FDAA), the Army Corps of Engineers coordinated a massive snow removal effort among local, state and federal levels of government. When the limited number of community snow plows and other equipment proved to be inadequate for the huge job, the Corps went into action. Working day and night, Corp's emergency operations center people at Waltham, MA., and in the field located, negotiated and contracted for 4,693 pieces of snow removal equipment administered by 1,988 Corps-negotiated contracts.

In Connecticut—which received the least snow—a Corps representative was at the state capitol almost immediately, helping the State Department of Transportation obtain contracts for snow removal on the highways and in the communities. In Rhode Island, hardest hit, the engineers' biggest difficulty was just getting into Providence. The first Corps employee made it into the civil defense regional center there on foot! Fifty-five more engineers, biologists and others eventually joined him and assisted 27 communities, while assuming all contracts in the state at the request of FDAA. In Massachusetts, FDAA asked National Guard and Army troops to clear the major highways, with the Corps helping communities. The Corps' field staff helped 128 Bay State towns clear a total of 4,000 miles of snow-covered streets.

The thousands of snowplows and other equipment rented by the Corps came primarily from the three snowbound states, but machines from New Hampshire, Vermont and New York were also hired—at times from telephone book yellow pages. ■

Army Engineers to Aid EPA in Sewage Treatment Grant Program

The U.S. Army Corps of Engineers will assist the Environmental Protection Agency (EPA) in reviewing and inspecting the construction of hundreds of new sewage treatment plants around the country under a new interagency agreement.

The multi-billion dollar construction program, conducted by EPA under the Federal Water Pollution Control Act of 1972, is a key means of cleaning up pollution in the nation's rivers and streams. The law calls for a level of water quality to support fish and recreational use by 1984. Nearly 4,000 sewage treatment plants are now under construction.

According to EPA Administrator Douglas M. Costle, "The Corps' construction expertise will help us ensure that these plants are built right, that the money is being spent properly, and that construction timetables are being met."

Lieutenant General J. W. Morris, Chief of Engineers, said that the Army Corps of Engineers "welcomes this opportunity to assist EPA in this important construction effort to improve the quality of the nation's waters in the years ahead. Under this agreement, the Corps will be able to bring its long experience in water resources management to bear in this critical area. The Corps is ready to begin immediately."

Under the terms of the agreement, the Corps of Engineers will provide three major services:

1. Following EPA project approvals and prior to bidding, the Corps will review construction details in plans and specifications of a proposed facility.
2. Ensure that projects approved by EPA are bid, contracted for, and constructed in accordance with the highest standards of the construction industry; and
3. Provide continuous on-site presence during construction of projects costing about $50 million or more. Approximately 100 treatment facilities are in various stages of construction. ■

Campground Restoration at Lake Lanier

by David W. Kern

After years of neglect, one of the most popular spots on the Corps of Engineers' most popular recreation lake has been revitalized and has a new purpose. The spot is Sawnee Recreation Area, about a mile west of Buford Dam on the 38,000-acre Lake Lanier, Georgia. A three-month restoration project costing about $200,000 has converted an eroding, over-used site with run-down facilities into an overnight camping area providing an ideal shoreline location and full facilities.

Restoration of the site illustrates how recreation area managers must take into consideration both the physical environment and its users in order to see that resources are used wisely and preserved. A task force set up to develop a program for restoring recreation areas around the lake established four goals for the wooded, 32-acre Sawnee area:

1. **Eliminate mixed day and overnight use.** With 37 camping spaces, 31 picnic sites, a shower-restroom building, a boat launching ramp and a 15-car and trailer parking lot, the area has attracted people with varying—and conflicting—purposes in mind, from partying to family camping.

2. **Limit the number of people allowed on the site in order to reduce damage to natural resources.** Some 200,000 visitors used the site annually. Both along the

Mr. Kern is a landscape architect with the Environmental Engineering Branch, South Atlantic Division, U.S. Army Corps of Engineers. Photos are by the author.

shore and upland, overuse had led to erosion of the thin rocky soil from the 10 to 20 percent slopes.

3. **Design recreation facilities that suited the physical site and periodic changes in water level.**

4. **Create a functional, enjoyable, and aesthetically pleasant family recreation experience for the public.**

The task force decided that, to eliminate mixed use of the Sawnee area, the site would be restricted to overnight camping. Camping was chosen because this was already the predominant use and because a day use area, with picnicking, swimming, and fishing facilities, exists only a half-mile away. Furthermore, some camping facilities—such as the shower-restroom building—were already there. Picnic sites were thus converted to camping sites. To limit the number of users, a control station was built at the entrance road, and a park attendant there will collect fees, provide information, and, planners hope, reduce rowdyism and vandalism. When the 55 campsites are filled, the attendant will close the site. At a maximum of eight people and two campsites per acre, there will be plenty of elbow-room for each visitor, and the site will suffer less damage.

To improve the physical site itself, a crew of two dozen workers terraced the campsites, built gravel and railroad-tie walks, and surfaced heavy use areas with granite pebbles. Landscaping the site this way not only provides level areas for campers but also cuts down sheet erosion from the slopes. Along the shore, the crew installed gabions (rock-filled wire baskets) to control erosion. With a flat surface and vertical face, the gabions make access to boats easy and provide places to sit and fish. They form steps, so visitors can always reach the water even though its level fluctuates.

To create a functional, enjoyable, and pleasant recreation area, manmade objects were built with native materials. Wooden guard posts were used instead of metal, and structures in the play area were built of timbers. The concrete block shower-restroom building was remodeled with cedar siding, shake shingles, stone walks and landscape planting. Clearing vegetation from natural beaches completed renovation of the campsite. ■

The work crew prepares a campsite at Sawnee Recreation Area, Lake Lanier.

While the lake is drawn down, workers install gabions to prevent further erosion of the shoreline.

"Midcourse Corrections" in Water Pollution Law

The new Clean Water Act of 1977 makes a host of "midcourse corrections"—some of them major—in Federal clean water policy originally set by the Federal Water Pollution Control Act in 1972. Provisions of the new law extended deadlines for meeting clean-up goals; others expand regulation of toxic discharges and encourage new sewage treatment technologies. Specifically:

☐ **Municipalities'** deadlines for beginning secondary sewage treatment can be extended up to six years under certain circumstances. Funding authority for treatment plant construction grants is extended five years. Also, some existing municipal plants could discharge sewage offshore without secondary treatment, provided the state agreed and water quality would not diminish.

☐ **Industries** must install "best practical control technology" by January 1, 1979. The old deadline was last July 1. The deadline for installing "best available technology" (BAT) to control conventional pollutants is extended one year to mid-1984. BAT for nonconventional pollutants must be installed by mid-1987. For 65 types of toxic chemicals, EPA will set discharge standards, and BAT must be installed by mid-1984, a one-year extension. EPA can add to or delete from the list of toxics. Also, EPA can require industries, by state, to use "best management practices" to limit toxic and hazardous pollutants.

☐ **Alternative sewage treatment** technology will qualify for 85 percent federal contribution to municipalities' total construction costs, compared with 75 percent for conventional technology. More than 25 percent of awards will go to alternative technology by 1981. Furthermore, in coming fiscal years, all grant applicants must consider alternative technologies before requesting funds. For industries, coming up with alternative technologies can qualify them for an extension of the BAT deadline to mid-1987.

☐ **Rural landowners** are not required to obtain Corps of Engineers wetlands dredge and fill permits (Section 404 permits) for normal farming, forestry and ranging activities—a clarification of existing policy. Also, Federal projects specifically okayed by Congress are exempted from the permit requirement unless the discharge contains a toxic substance.

☐ **Control of nonpoint pollution** will be assisted by a Department of Agriculture program to provide rural landowners with technical assistance and to pay part of the costs of conservation practices.

☐ **Those responsible for spills** of oil and hazardous substances will bear more of the financial responsibility for clean-up, and the jurisdiction of the law is extended from 12 to 200 miles offshore.

☐ **Either the House or Senate** can veto any EPA regulation issued under the new law. ■

Exotics On The Increase

The Sport Fishing Institute reports that some 26 exotic species of fish—plus five hybrids—have established spawning populations in the southeastern states—primarily Florida.

Inadvertant introductions accounted for 23 of the species and all the hybrids. Most have been associated with the ornamental aquarium fish trade. Some of the fish escaped from fish farms, some were discarded by aquarium hobbyists and, in other cases, ill-advised fishermen illegally transferred the exotics to open water.

The impact of these exotic species remains to be seen. ■

Soil Conservation Society Names Greiner

William H. Greiner, director of the Iowa Department of Soil Conservation, has been named chief executive officer of the Soil Conservation Society of America. He succeeds H. Wayne Pritchard, who has retired after 26 years in the post.

The Society is a private, nonprofit scientific and educational association of professional conservationists dedicated to promoting the wise use of land and related natural resources. It was founded in 1945 and has more than 15,000 members in the United States, Canada, and 80 other countries. The Society's international headquarters is located in a rural area near Ankeny, Iowa. ■

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Ocean Dumping Manual Available

The Environmental Protection Agency recently announced the availability of a manual that sets forth the procedures for conducting bioassays on the liquid, suspended particulate, and solid phases of dredged material to determine whether such material is acceptable for ocean disposal.

The dredged material manual is a joint product of EPA and the Corps of Engineers. It discusses the requirements of EPA's Criteria for the Evaluation of Permit Applications for Ocean Dumping of Materials and provides detailed guidance on sediment and water sample collection; analysis of the liquid phase; bioassays of liquid, suspended particulate and solid phases; estimation of bioaccumulation potential; and estimation of initial mixing.

Copies of the manual are available from Chief, Marine Protection Branch (WH-548), Environmental Protection Agency, Washington, D.C. 20460. ■

"Water . . . What the State is Doing to Manage This Life Support Resource" is an eight-page foldout brochure available free from the Department of Environmental Protection, State of New Jersey, Division of Water Resources, Box 2809, Trenton, NJ 08625. In addition to explaining the work of the division, the brochure contains photographs and interesting facts about water availability, supply, cost and the like. ■

Changes of Command

Colonel William E. Vandenberg became South Pacific Division Engineer, San Francisco, January 8, 1978. Before this appointment, **Colonel Vandenberg** served as Deputy Division Engineer of the South Pacific Division.

In his new position, **Colonel Vandenberg** will be responsible for directing military construction in eight Western states, and civil works programs in California, Utah, Nevada, Arizona and portions of Oregon, Idaho, Wyoming, Colorado and New Mexico. The South Pacific Division accomplishes its programs through engineer districts in Sacramento, San Francisco and Los Angeles.

He succeeds **Brigadier General Richard M. Connell** who has been reassigned as Director of Military Construction, Office of the Chief of Engineers, Washington, D.C. **General Connell** will be responsible for providing construction support for the Army, Air Force and various Federal agencies, including the National Aeronautics and Space Administration. He succeeds **Major General Bates C. Burnell** who has been reassigned as Assistant Deputy Chief of Staff for Logistics, Department of Army Headquarters. ■

Coming Events

23rd Summer Institute in Water Pollution Control at Manhattan College in Bronx, N.Y., May 22-28.

33rd annual meeting of the Soil Conservation Society of America at Denver, Colo., July 30-August 2. ■

Bagged in the Mail

In Lieu of Dams . . . Revisited

Editor:

I am sure that I am but one of many who read with interest Brent Blackwelder's article in the Fall 1977 issue of **Water Spectrum.** His piece brings out many points that need to be discussed . . . but he also missed a few. I would like to see the record more complete without picking a fight, particularly since Dr. Blackwelder was a "guest" on the **W.S.** pages.

I think it is fair to say that the day of canal building is over. The Tenn-Tom may well be the last new waterway of any size constructed in this country. We may see a few short stub end canals, but nothing of any consequence. Transportation corridors, both rail and waterway, are in about the same final phase of development. This then drastically changes the focus of the issue from new waterways vs. more trains as suggested by Dr. Blackwelder to that of deciding which existing right-of-way can provide the most efficient transportation. In other words, should we increase the size of selected existing locks or place more reliance on the railroads?

Elsewhere in this same article Blackwelder talks about evacuation vs. structural flood control projects as if these two extremes were the only possible choices. Recent lessons learned in the Cumberland River floods of 1977 have shown that temporary evacuation as part of an overall flood protection plan can go a long way towards meeting the needs of all affected parties. Temporary evacuation can reduce flood damages, save lives, be economically efficient, have no detrimental environmental effects, and permit the property owners to use and enjoy their homes. This type of in-between solution is worthy of consideration by both the engineers and the environmentalists. With the "howevers" I noted above, I thought Brent Blackwelder did a fine job in presenting the environmentalist's point of view.

E. R. Heiberg III
Brigadier General, USA

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Low profile reefs with lots of hiding places provide excellent homes for juvenile fish like these tomtates and striped grunts in Biscayne National Monument, Florida. When grown, some species leave the reef, others stay. *See Artificial Reefs, page 24.*

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